

# THE GENUS *PACHYSANDRA* (BUXACEAE)<sup>1</sup>

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The genus *Pachysandra*, a member of the Boxwood Family (Buxaceae), is a small group of shrubs, subshrubs, and perennial herbs of relatively low stature. Of the four species currently recognized as comprising the genus, three are indigenous to eastern Asia, one to eastern North America.

*Pachysandra* was last treated monographically in 1859 by Baillon. At that time, three species were included in the genus, representing only two of those presently recognized. Since publication of Baillon's monograph, additional information concerning the genus has been limited to uncorrelated, often very brief, descriptions of the taxa as they were discovered. Consequently, no key to the infrageneric taxa exists that incorporates all known members of the group. It is apparent then that revision of the genus is necessary. The purpose of this paper is to present a more complete systematic treatment of *Pachysandra*.

The systematic treatment is based primarily upon characteristics of external morphology correlated with the geographical distribution of such morphological groups as were delimited. Morphological information was obtained from herbarium specimens representing the entire *Pachysandra* collections of 52 herbaria and from living specimens of *P. procumbens* and *P. terminalis*. Information concerning geographical distribution was derived from collection data accompanying herbarium specimens and from considerable field work with the indigenous American species.

## HISTORY OF THE GENUS

The original account of *Pachysandra* as a genus was published in Michaux's *Flora Boreali-Americana* in 1803. The genus was based upon the single species, *Pachysandra procumbens*, published in the same work. The specimen upon which the type species is based was collected by Michaux during his travels across the western Allegheny Mountains and through Kentucky in the 1790's.

In 1845, Franz Phillip von Siebold and J. G. Zuccarini described a second species, *Pachysandra terminalis*. The original description was based upon material collected in Japan by Siebold.

Baillon, in 1859, removed three genera—*Buxus*, *Sarcococca* and *Pachysandra*, from the Euphorbiaceae and placed them in a newly established family, Buxaceae. The latter was distinguished from Euphorbiaceae on the basis of the position of the ovules. In his monograph of the Buxaceae,

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<sup>1</sup> Portion of a doctoral dissertation written at Vanderbilt University.  
*SIDA* 3 (4): 211—248. 1968.

Baillon described in considerable detail the morphology of the two species of *Pachysandra* known at that time, namely, *P. procumbens* and *P. terminalis*.

*Pachysandra axillaris*, the third species, was described as new by Adrien Franchet in 1889. The original description was based upon material collected by Delavay in western China, in the province of Yunnan.

A third Asiatic species, *Pachysandra stylosa*, was described in 1908 by S. T. Dunn. The original description was based upon material collected in Fukien, China, by native assistants to Dunn during an expedition to that province in 1905.

Léveillé, whose contribution to systematic botany is generally regarded as more fortuitous than analytical, described as new, *Pachysandra Bodinieri* in 1913 and *P. axillaris* Franch. var. *kouytchensis* the following year. Both names were subsequently relegated to the synonymy of *P. stylosa*.

In 1913, Hayata described *Pachysandra axillaris* var. *tricarpa* on the basis of material collected in Taiwan (Formosa).

The most recent treatment of *Pachysandra* is that of Handel-Mazzetti (1929-1937). This work, however, is neither comprehensive nor definitive. Of the species described to this time, only *P. axillaris* and *P. stylosa* are included. The work does include the description of a new variety, *P. stylosa* var. *glaberrima*.

#### GEOGRAPHICAL DISTRIBUTION OF THE GENUS

Representatives of the genus *Pachysandra* presently occur in eastern Asia and eastern North America in areas of vegetation commonly considered as major remnants of great mesophytic forests that had a relatively uniform and widespread distribution throughout the Northern Hemisphere during the Tertiary period. These two areas, lying between latitudes 30 and 50 degrees north, are very similar geographically and, according to geologists, are quite old. They have remained largely undisturbed by major geological changes since the close of the Paleozoic period and probably have not been submerged since the close of the Cretaceous (Li, 1952).

In 1840, Asa Gray called attention to the floristic similarity existing between these two disjunct areas and pointed out certain entities, mainly genera, common to both. Subsequently, the subject of eastern Asia-eastern North America floristic relationships attracted the attention of many botanists, particularly plant taxonomists and phytogeographers. As the flora of each of these two regions became better known, more genera were found to exhibit a strikingly similar disjunct distribution; and at present no less than 150 genera, including *Pachysandra*, are recognized as common to the two areas.

The Asiatic species of *Pachysandra* occur in China, Japan and in Taiwan (Map 1). *Pachysandra terminalis* occurs both in Japan and China,

but it is the only species of the genus native to Japan. Data accompanying herbarium specimens indicate that this species is distributed throughout the main island of Honshu and Hokkiado, usually occurring in mesophytic forests of mountainous regions. In China it occurs in the central provinces of Kansu, Chekiang, Shensi, Szechwan, Hupeh and Yunnan.

*Pachysandra axillaris* is known only from central and western Yunnan. It occurs at altitudes of 7,200 to 10,000 feet, usually on the slopes of ravines, at the foot of bluffs, and at the margins of thickets.

*Pachysandra stylosa* is widely distributed throughout China over areas of considerable relief and of climatic and ecologic diversity. It is known to occur in Fukien, Kiangsi, Kweichow, Yunnan, Hupeh, Szechwan and Taiwan (Formosa). It is regionally sympatric with *Pachysandra terminalis* in Hupeh and Szechwan. The habitat of *Pachysandra stylosa* is similar to that of the other species. It grows on the slopes of ravines and in shaded gorges.

The single American species, *Pachysandra procumbens*, is distributed from central Kentucky southward through central and eastern Tennessee and western North Carolina into Mississippi, Alabama and western Georgia. It also occurs in the Tunica Hills area of Louisiana and in Jackson County, Florida (Map 2). It is usually found in deciduous woods, most often on gentle to rather steep slopes of shaded ravines and generally near a small stream. The soil of these sites is frequently calcareous, a mixture of moist clay and chert with a circumneutral pH.

Braun (1950) considers *Pachysandra procumbens* a characteristic herbaceous plant of the Western Mesophytic Forest Region, an area having as its eastern boundary the western escarpment of the Cumberland and Allegheny Plateaus and as its western boundary the loess bluffs of the Mississippi River. She states that although commonly thought to be rare, it is an abundant plant of mesophytic woods of that region.

*Pachysandra procumbens* has been described as disjunct in rich woods of the Marianna Red Lands of northern Florida and of the Tunica Hills of southern Mississippi and adjacent northern Louisiana (Harper, 1914; Brown, 1938). Both areas represent Tertiary forest extensions and are very old geologically. *P. procumbens* also occurs in the Tennessee River hills of northeastern Mississippi, an area which is transitional between plateau and coastal plain.

In Tennessee, the species occurs only in the central and eastern part of the state. It has been reported from the vicinity of Memphis, but there is no specimen to support this record.

The presence of three Asiatic species of *Pachysandra* and the apparently relict one in the United States suggests that the genus may have evolved in Asia. Recent discovery of fossil pollen of *Pachysandra* in the Western United States is good evidence that the genus was more widely distributed during the geologic past.

Gray (1959, personal communication) and Wolfe (1959, personal communication) have reported the discovery of fossil *Pachysandra* pollen from Miocene (late Tertiary) deposits in Oregon. Wolfe reports fossil pollen from early Miocene sediments collected in the Clackamas River basin about 60 miles southeast of Portland. Here the associated flora is a very rich one, comparable to that of the present mixed mesophytic forests of eastern North America and eastern Asia. Wolfe also reports the finding of leaves of an extinct species of *Pachysandra* that he considers most similar to *P. procumbens*.

Even older records of *Pachysandra* were reported by Leopold (1959, personal communication) who found fossil pollen of *Pachysandra* in Upper Cretaceous sediments of southwestern Wyoming (Evanston formation) and also in the Lower and Middle Paleocene (Tertiary) of the Wyoming, North Dakota, South Dakota, and Montana areas (Ft. Union formation). She has found the microfossils to be extremely common in more recent sediments in the upper third of the Fort Union and in the lowermost Wasatch formation in the same area (Upper Paleocene and Lower Eocene) and states that they represent pollen of the *Pachysandra procumbens* type. Eocene sediments from various localities in Oregon and sediments of Oligocene and Miocene age from the central western states show no *Pachysandra* microfossils.

According to Leopold, pollen analyses of sediments deposited during the Paleocene and Eocene indicate that *Pachysandra* grew in association with species of *Sphagnum*, *Pinus*, *Sequoia*, *Zelkova*, *Ulmus*, *Carya*, *Juglans*, *Alnus*, *Nyssa*, *Schizandra*, *Betula*, *Corylus*, and *Platanus*. Many species within these genera are apparently most closely related to those now growing in the eastern United States and eastern Asia.

The absence of *Pachysandra* pollen in the Oligocene of the Rocky Mountain area suggests that at some time during the Eocene the genus disappeared from the Central West. Its departure was probably brought about by the increasing provinciality of the climate during the middle Tertiary. Instead of the regionally humid, very warm temperatures and subtropical conditions of the late Paleocene and early Eocene, the Oligocene was locally very dry with warm temperature conditions.

In Oregon, *Pachysandra* pollen is absent from the Eocene deposits but present in the Miocene deposits. This suggests that in the interval between the two periods the genus may have migrated from the Central West to Oregon where it was eventually eliminated.

The present localization of *Pachysandra* in the southeastern United States apparently resulted from its migration southward during the latter part of the Tertiary in response to the increasingly colder conditions. The uplift of the Rocky Mountains and the resulting increased aridity of the interior probably led to the segregation of communities on the basis of the moisture requirements of their constituent species and the retreat eastward of those with highest demands. This resulted in the localization

in the Appalachian Mountains and plateau regions of remnants of the mixed forests of the late Cenozoic. *Pachysandra* most likely was associated with these remnants which have survived the geological changes of the past few million years.

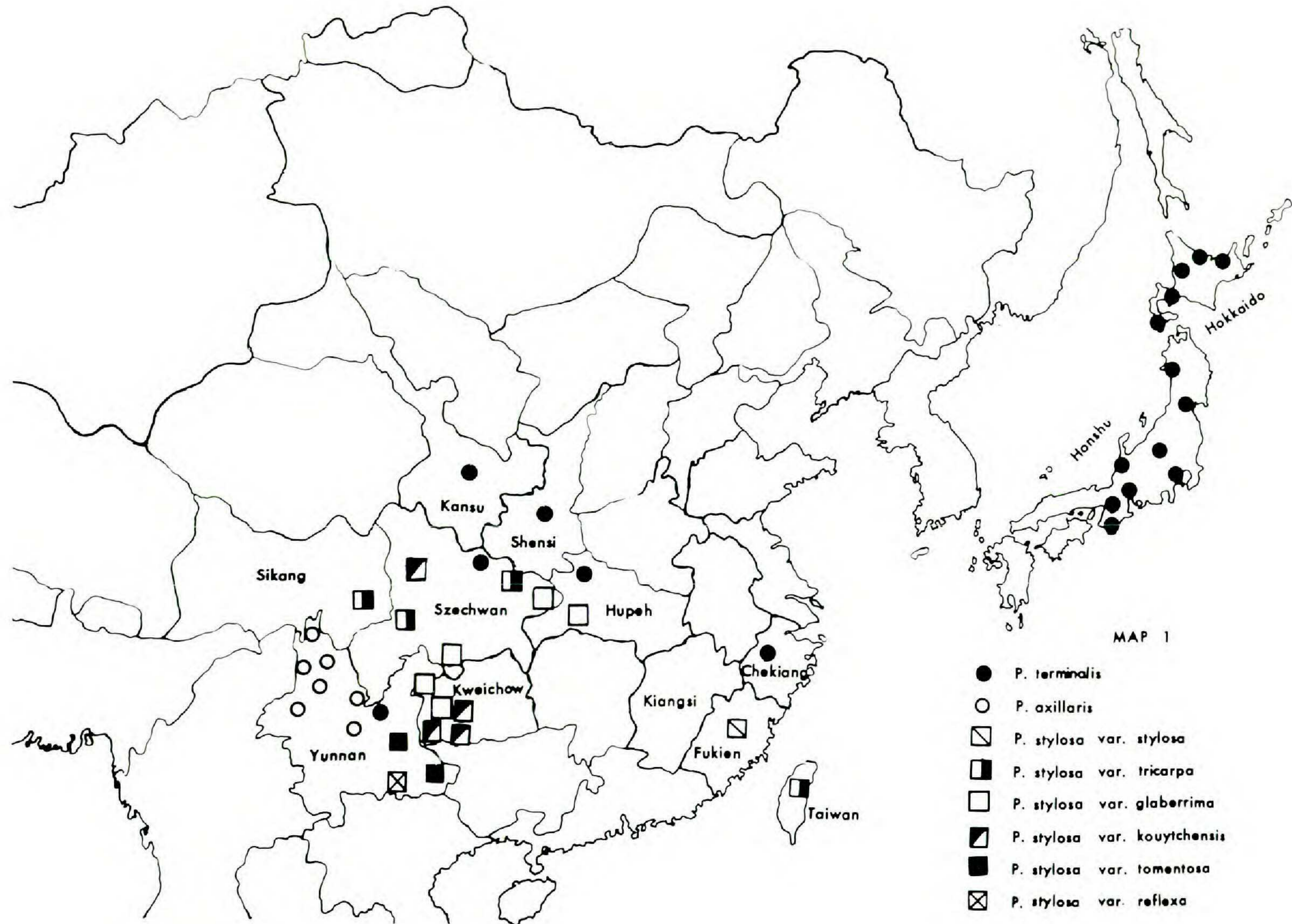
#### SYSTEMATIC TREATMENT

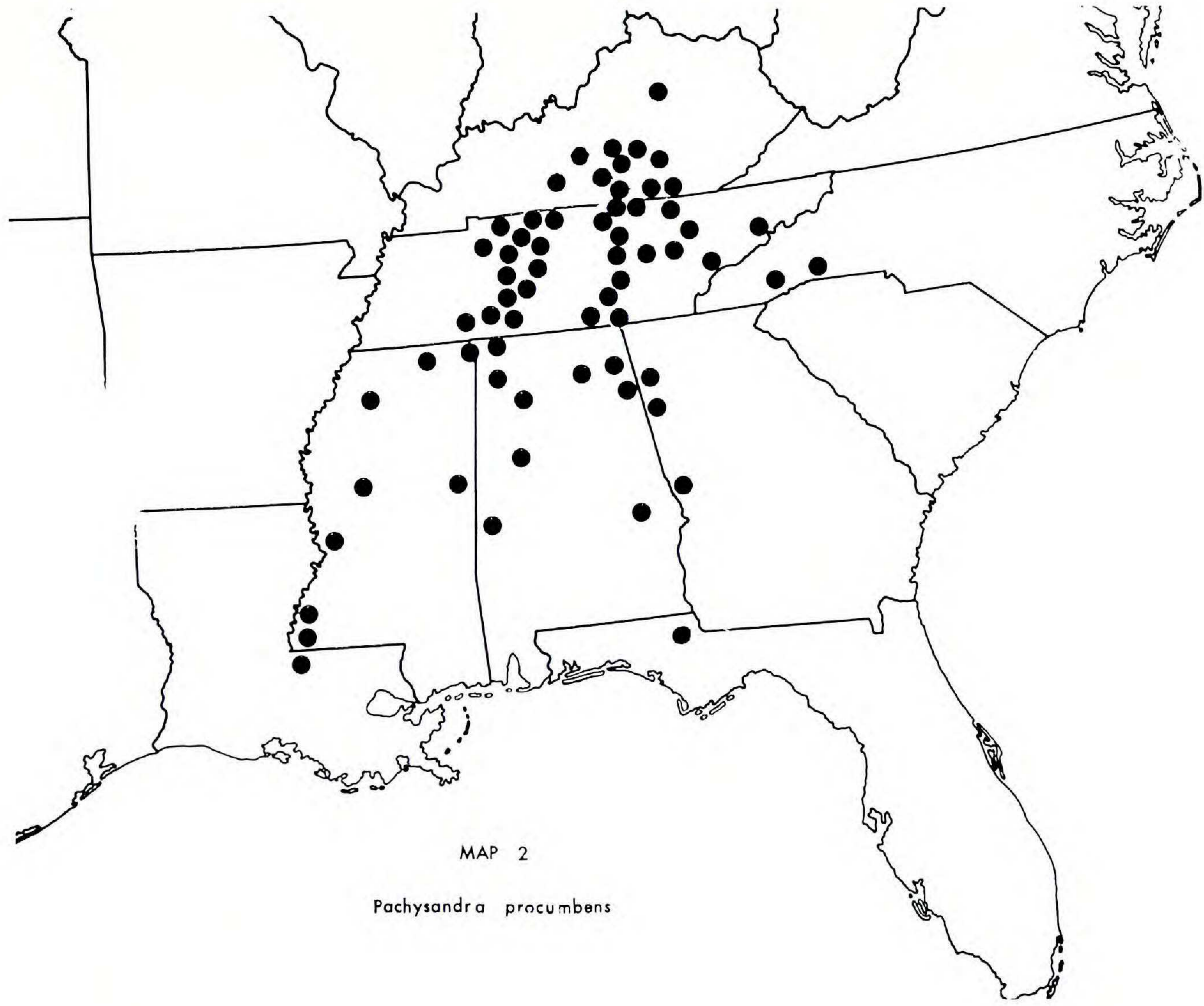
PACHYSANDRA Michx. Fl. Bor.-Amer. 2: 177. 1803. Type-species: *P. procumbens* Michx.

Erect, decumbent or prostrate shrubs, subshrubs or perennial herbs, usually from ligneous or fleshy rhizomes with fibrous roots. Stems branching sympodially. Pubescence of simple, uniseriate trichomes. Leaves evergreen or semi-evergreen, simple, alternate, exstipulate, petiolate, pinnately 3-nerved, the blades glabrate or pubescent, variously toothed, subdentate to nearly entire. Inflorescences spicate, axillary or terminal; flowers unisexual, apetalous. Staminate flowers 5-40, sessile, occupying the upper portion of the floral axis; sepals 4, decussate, imbricate, ciliate, subtended by a single ciliate, pubescent bract. Stamens 4, distinct; filaments long-exserted, attached to the receptacle around a central, rectangular nectary; anthers oblong-linear, rotund to sagittate in shape, dorsifixed, introrse, longitudinally dehiscent, the connective sometimes prolonged as an appendage; pollen spheroid, with a polygonal ornamentation. Pistillate flowers 1-7, pedicellate, sessile or subsessile, inserted below the staminate at the base of the floral axis, subtended by several (7-13) distinct, imbricate, herbaceous bracts; ovary superior, 3- or sometimes 2-carpellate, each carpel with 2 locules separated by a false partition, each locule containing a single pendent, anatropous ovule; styles 3, sometimes 2, subulate to linear, erect, becoming recurved in fruit; stigma linear or linear-lanceolate, papillose, usually sulcate, covering the inner surface of the style branches. Fruit capsular or baccate, indehiscent. Seed with or without a micropylar caruncle, trigonal, the smooth, glossy testa hard and dry at maturity, dark brown or black in color; endosperm whitish and oily; the embryo straight, the cotyledons considerably broader than the radicle.

#### KEY TO THE SPECIES

- A. Gynoecium two-carpellate; inflorescences terminal (Native to Japan, but found in China and Formosa). . . . 1. *Pachysandra terminalis*.
- A. Gynoecium three-carpellate; inflorescences lateral, arising from the aerial axis in a position axillary to basal bracts, their scars, or foliage leaves. . . . . B
- B. Inflorescences usually basal to the aerial stem, subtended by bracts, only rarely by foliage leaves; filaments clavate; aerial stem and rhizome herbaceous; leaves semievergreen, becoming mottled in color in age; stem becoming procumbent in age. (North America). . . . . 2. *Pachysandra procumbens*.
- B. Inflorescences axillary to foliage leaves; filaments linear, not con-





MAP 2

*Pachysandra procumbens*

spicuously clavate; aerial stem and rhizome ligneous; leaves evergreen; stem erect. . . . . C

C. Leaf blades coarsely dentate or distinctly serrate to crenate,  $\frac{1}{2}$  to  $\frac{3}{4}$  of distal portion toothed, truncate to subcordate at the base, both surfaces beset with hair; marginal area of the lower surface usually densely hairy; the margin ciliate.

(Yunnan, China) . . . . . 3. *Pachysandra axillaris*.

C. Leaf blades only sparsely dentate, subentire or rarely entire,  $\frac{1}{4}$  to  $\frac{1}{2}$  of distal portion toothed, obtuse to oblique at the base, the upper surface glabrous, the margin eciliate (Widely distributed in China). . . . . 4. *Pachysandra stylosa*.

1. PACHYSANDRA PROCUMBENS Michx., Fl. Bor.-Am. 2: 177. 1803. "Hab. in occidentalibus montium Alleghanis." (P—Type, photograph examined). *Pachysandra erecta* Raf. ex Baillon: Monogr. Bux. et Stylocer., 1859.

Rhizomatous, colonial, herbaceous perennials with adventitious roots, the few to many, leafy aerial stems, 1.5-4 dm in height, becoming procumbent in age, persistent over winter and abscissing after anthesis. Rhizome subterete, 3-10 mm in diameter, white or occasionally tinged with pink, with numerous buds and bud scale scars. Aerial stem terete, 3.5-5 mm in diameter, 1.5-3 (-4) dm tall, unbranched, green in color, sometimes tinged with red, strigose, the trichomes increasing in number from the base upward to the leaves, upper portion foliate, lower portion naked or with short green to reddish bracts becoming brown and deciduous in age. Leaves (7-) 9-10 (-12) in number, approximate at the summit of the aerial stem, gradually diminishing in size upwards to the terminus of the stem, lowermost leaf blades (4-) 6-8 (-10) cm wide, membranous in texture, broadly ovate to obovate, dark green above becoming silvery mottled in age, dull green beneath, distinctly trinerved, the veins hispid, these prominent and depressed on the adaxial surface, the midrib and lateral veins prominent and elevated on the abaxial surface, the margin ciliate, the basal portion entire, acute or cuneate, becoming dentate to crenate toward the apex, the teeth nonapiculate, the petiole densely pubescent, the lowermost 2-5 cm long, one-third to one-half the length of the blade. Inflorescences basal to the aerial stem, (0-) 1-3 (-10) per shoot, spicate, cylindrical, 6-12 cm long, each with 18-38 staminate flowers and 1-3 (-7) pistillate flowers. Staminate flowers each subtended by a single, long-ciliate, broadly ovate, pubescent bract 2-3 mm long, 2.5-3 mm wide at the base, acute to acuminate at the apex; calyx of 4 subequal, ciliate, red to purple-tinged sepals, the outer two ovate, 3.5-4.5 mm long, 3-4 mm wide, acute at the apex, slightly keeled, with trichomes along the midrib, the inner two broadly ovate, concave, obtuse at the apex, retuse, glabrous, 3.5-4-5 mm long, 3-4 mm wide; stamens 8-13 mm long, 2-3 times as long as the sepals, with compressed-clavate, white, glabrous, fleshy filaments, 6-9 mm long, 1-2 mm



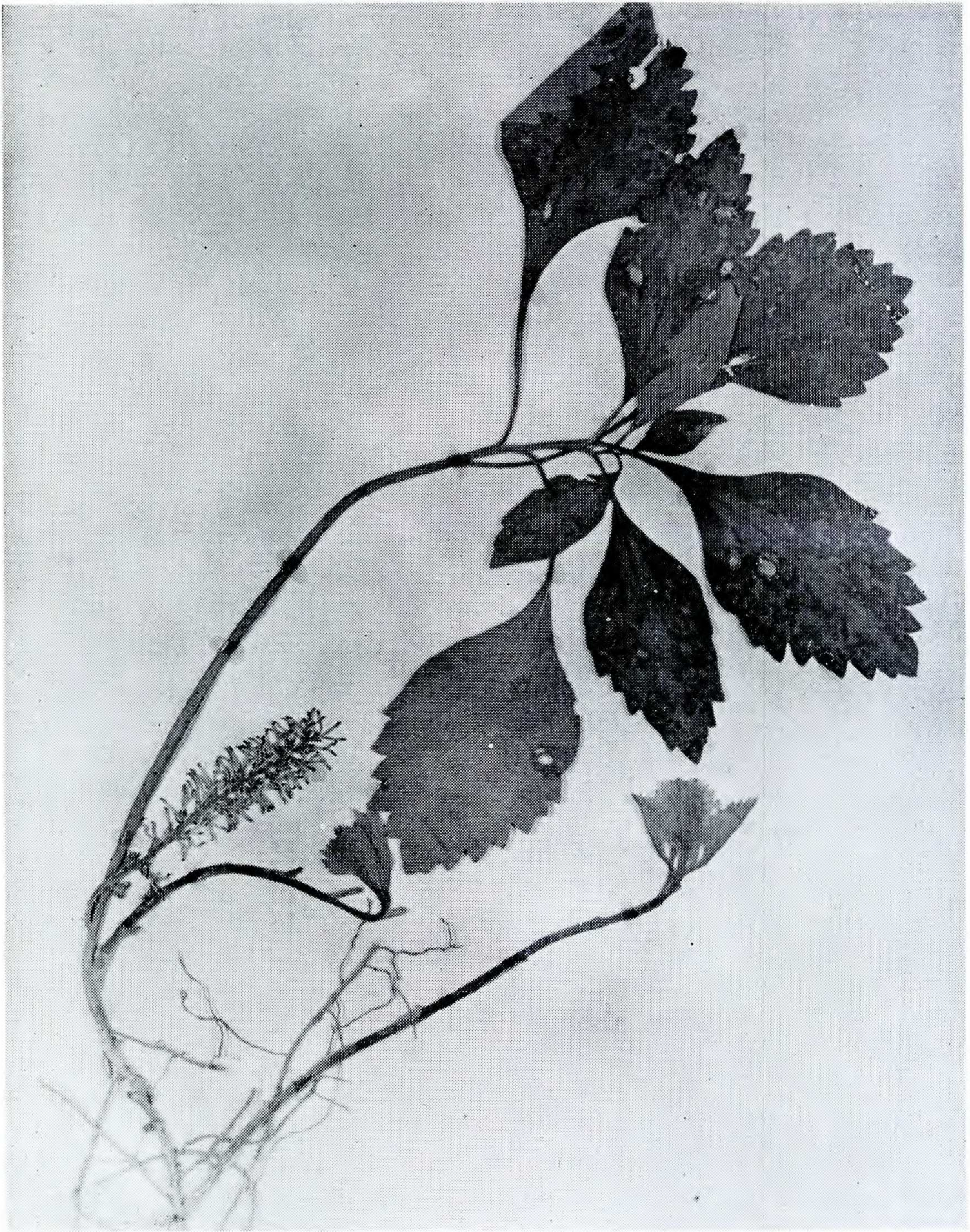


Fig. 1. *Pachysandra procumbens* Michx.

wide, tapering at the base, the elongate, minutely-apiculate, red to purple-tinged anther more or less deflexed at the connective at anthesis, 2-3.5 mm long, 1-1.5 mm wide. Pistillate flowers, each short-pedicellate to subsessile or sessile, the pedicel increasing in length from 6 mm at anthesis up to 13-16 mm in fruit, multibracteate, the lower bracts subtriangular, concave to keeled, pubescent, 3-4 mm long, 2-3 mm wide at

the base, the apex acute, the upper 6-7 bracts ovate to elongate ovate, 3-4.5 mm long, 2.5-3 mm wide, the apex obtuse. Gynoecium 3-carpellate, shallowly tri-lobed, the pubescent, reddish green ovary 3-3.5 mm long, 2-2.5 mm in diameter; styles 3, erect to divergent, linear to lanceolate, 5-7 mm long, 2-2.5 mm broad, stigmatic surface sulcate, introrse, papillose. Fruit capsular, globose, 3-lobed, reddish brown in color, densely pubescent, styles persistent, becoming recurved when dry, 13-16 mm high, 8-12 mm in diameter when fresh, the carpels firmly united and never separating in drying but the whole fruit becoming detached at the base, falling off thus freeing the seeds. Seeds 3.5-4.5 mm long, 2-2.5 mm wide, glossy black in color, trigonous, carunculate.

Occurring chiefly on calcareous, clayey soils on the slopes of ravines in deciduous woods in central Kentucky, central and eastern Tennessee, western North Carolina, Alabama, Georgia, Mississippi, Jackson County, Florida and West Feliciana Parish, Louisiana.

KENTUCKY: Adair Co.: near Canoe Creek, rich woods, 10 mi n of Columbia, *Gibson and Watson 273* (F). Fayette Co.: banks of Raven Creek, *Shacklette, Rogers and Harvill 21* (DUKE, GA, GH, IND, MIN, MO, NA, NY, PH, TENN, UC, WVA). Jefferson Co.: Old Heady Road, 10 mi s. e. of Jeffersontown, April, 1964, *Robbins*. McCreary Co.: South Fork, Cumberland River, 5 April 1934, *Braun* (CINC, GH, NY). Pulaski Co.: 2 mi. n.e. of Somerset, *Wherry and Pennell 13766* (MO, PH). Taylor Co.: Dempsey Kerr farm, on creek bank, *Shacklette 14781* (SMU). Warren Co.: near Jackson Ridge, Gaspar River, *Thacher 391* (GH). Wayne Co.: s w of Monticello, Beaver Creek, *Hodgdon 3883* (GH).

NORTH CAROLINA: Polk Co.: near state Highway 108 at Green River, 8 April 1960, *Freeman 605* (personal collection—2 sheets).

TENNESSEE: Anderson Co.: Key Spring, n. of Oak Ridge, *Warren 20174* (TENN). Blount Co.: ¼ mi from Highway 73 near Walland, *Robbins and Channell 0063* (VDB). Cheatham Co.: wooded hillside, Little Marrowbone Creek vicinity, 6 April 1940, *Mortimer* (US). Cocke Co.: Wolf Creek, *Ruth 1182* (E). Cumberland Co.: River bluff, Harriman, 6 May 1945, *Cain* (TENN). Davidson Co.: Ravine in deciduous woods at the edge of Highland Rim, s w of Ridgetop, 29 Apr 1957, *Quarterman* (GH). Franklin Co.: Elk River, below Patterson's Bridge, *Svenson 7630* (BKL). Hardin Co.: along Steele Creek, e of Savannah, *Sharp, Clebsch & Fairchild 9483* (TENN). Hickman Co.: bluff and bottoms, near Dickson Co. line, Garner Creek Bridge, *Sharp et al. 11896* (TENN). Houston Co.: moist deciduous woods above Wells Creek, n of Erin, *Quarterman & Stauffer 4908* (VDB). Jackson Co.: Haydenburg, December 1922, collector not given (TENN). Lawrence Co.: near Fall River, along e fork of Sugar Creek, *Sharp et al. 9727* (TENN). Lewis Co.: bottoms and bluffs of Trace Creek near bridge on Tenn. Highway 48, s w of Hohenwald, *Sharp et al. 10096* (TENN). Maury Co.: ravine w of Rockdale, *Svenson 9041* (BKL, GH). Montgomery Co.: upper region of Macadoo Creek,

*Clebsch & Brown 21551* (TENN). Morgan Co.: woods 2 mi n of Harriman, 5 April 1930, *Sharp* (GH). Pickett Co.: small cove on Dale Hollow Lake near camping area at Byrdstown Bridge, 18 March 1951, *Taylor* (NCU). Putnam Co.: Stamps Hollow, near Monterey, *Sharp 1710* (TENN, US). Roane Co.: Emory River bluffs, Harriman, *Underwood 2755* (TENN). Robertson Co.: Baker's Station, 23 March 1919, *Shaver* (PEABODY). Scott Co.: No Business Creek near South Fork River, *Shanks & Sharp 3870* (NY, TENN). Sumner Co.: South Tunnel, July 1883, *Gattinger* (GH). Van Buren Co.: near Cane Creek, Piney Creek Gulf, Fall Creek State Park, *Caplenor 566* (VDB). Wayne Co.: below Great Falls Dam, near Webb's Camp on Caney Fork, *Shanks et al. 5051* (TENN). William Co.: 7 mi s of Fernvale,  $\frac{1}{4}$  mi from Highway 96, *Robbins 0002* (VDB).

ALABAMA: Cherokee Co.: 1.5 mi e of Forney, 15 July 1932, *Wherry* (NY). Franklin Co.: Russelville, December 1941, *James 4* (MO). Lauderdale Co.: Bat Cave, 2.5 mi n of St. Florian, 14 Mar 1953, *Chermock* (UA). Macon Co.: 1.5 mi n w of Hanna (Hannon?), 9 May 1929, *Wherry* (NY). Sumter Co.: York, 1 February 1934, *Bennett* (NA). Tuscaloosa Co.: w of North River, about 7 m n of Tuscaloosa, 23 March 1935, *Harper 3307* (BH, GH, MO, NY, PH, US).

GEORGIA: Floyd Co.: ex Herb. Chapman (MO). Haralson Co.: Tallapoosa, April-May 1900, *Way 42* (US). Harris Co.: along Standing Boy Creek, north of Columbus, 4 June 1949, *Duncan 9688* (GA).

MISSISSIPPI: Adams Co.: Natchez, 1843, distributed per P.V. LeRoy (MASS). Noxubee Co.: s e of Starkville in Bluff Lake area, 4 April 1959, *Beckett 76* (MISSA). Tippah Co.: 8 mi w of Ripley, May 1934, *Mellen* (MISSA). Tishomingo Co.: n of Eastport, n e of Iuka, 27 April 1952, *Schuster A-7377* (DUKE, FSU, MISSA, VDB). Wilkinson Co.: Tunica Hills, Pinckneyville, *Brown 7035* (LSU).

FLORIDA: Jackson Co.: Florida Caverns State Park, *Smith 3041* (GA).

LOUISIANA: West Feliciana Parish: 1 mi w of Plettenberg Post Office, *Correll & Correll 10451* (A, DUKE, F, LSU, MO, NA, NY, PH).

The taxonomy of *Pachysandra procumbens* is not complicated, being distinct morphologically and the only representative of the genus indigenous to North America. The herbaceous, procumbent habit, the basal position of the inflorescences and the semievergreen leaves are characteristic features of the species.

During the course of this investigation the specimens representing the disjunct Florida population of *Pachysandra procumbens* were compared morphologically with plants from other parts of the range. While in most cases the Florida plants were found to be smaller and with a less well-developed rhizome system, these variations are not considered to be of taxonomic significance.

Several anomalies were observed among both living and herbarium

specimens of *Pachysandra procumbens*. The incidence of these teratological forms seemed to be greater among those plants grown in the greenhouse or under cultivation than among those growing in their natural habitat. The most common deviation from the normal was the location of the inflorescences in the axils of the leaves and at the terminus of the aerial stem instead of the usual basal position. Several herbarium specimens of cultivated *P. procumbens* had many well-developed inflorescences in the axils of the foliage leaves. In one case, small leaves had developed in the place of the bracts of the staminate flowers. This ability of *P. procumbens* to produce inflorescences in the axils of leaves and at the terminus of the stem may represent the primitive condition with the basal position of the inflorescence being a derived condition.

Less clear significance can be attached to the presence of 2 or 4 styles in the pistillate flowers and 5 stamens in the staminate flowers. It may be that the 2-carpellate condition is derived and the 4-carpellate is more ancestral. The 4-style condition is not the ultimate since 5 stamens have been found.

The leaves of *Pachysandra procumbens* most closely resemble those of *P. axillaris*, being similar in texture, in the distribution of hair over the surface, as well as in the general shape and tothing of the blade.

*Pachysandra procumbens* frequently has been reported native to West Virginia (Gray, 1908), and in some manuals it has been listed as occurring in New Jersey. As far as I have been able to determine there are no specimens to substantiate these reports.

2. PACHYSANDRA TERMINALIS Sieb. and Zucc., Ahb. Akad. Muench. 4: 142. 1845. *Pachysandra terminalis* var. *variegata* (J.B.S. Nort.) Manning ex Hegi, Ill. Fl. Mittel-Eur. 5, 1: 203. 1924.

Rhizomatous, colonial, decumbent evergreen herbaceous perennials, with adventitious roots about 2 mm in diameter, the leafy aerial stems 1-3 dm in height. Rhizome fleshy, subterete, striate, 3-5 mm in diameter, with numerous leaf scars. Aerial stem simple or sparingly branched, olive green in color, glabrous or glabrate, terete, 3-5 mm in diameter, becoming angular when dried. Leaves in clusters of 5-9 at the summit of the stem and at intervals of 5-9 cm along the stem, the coriaceous, ovate to obovate, sometimes deltoid, cuneate blade, 5-7 cm long, 3-4 cm wide, glossy dark green above, pale green beneath, prominently 3-nerved, the veins puberulent, prominent and elevated on the adaxial surface, prominent but not elevated on the abaxial surface, the margin eciliate, the basal portion entire, becoming coarsely dentate to serrate toward the apex, the teeth deltoid, non-apiculate, the petiole canaliculate, glabrous, 1-3 cm long. Inflorescences terminal, solitary, spicate, cylindrical, 2-3 cm long, each with 15-20 staminate flowers above the 2-5 pistillate. Staminate flowers each subtended by a single, ciliate, coriaceous, triangular bract 1.5-2 mm long, 1.5-2 mm wide at the base, acute to acuminate at the apex and accompanied laterally by two opposite,

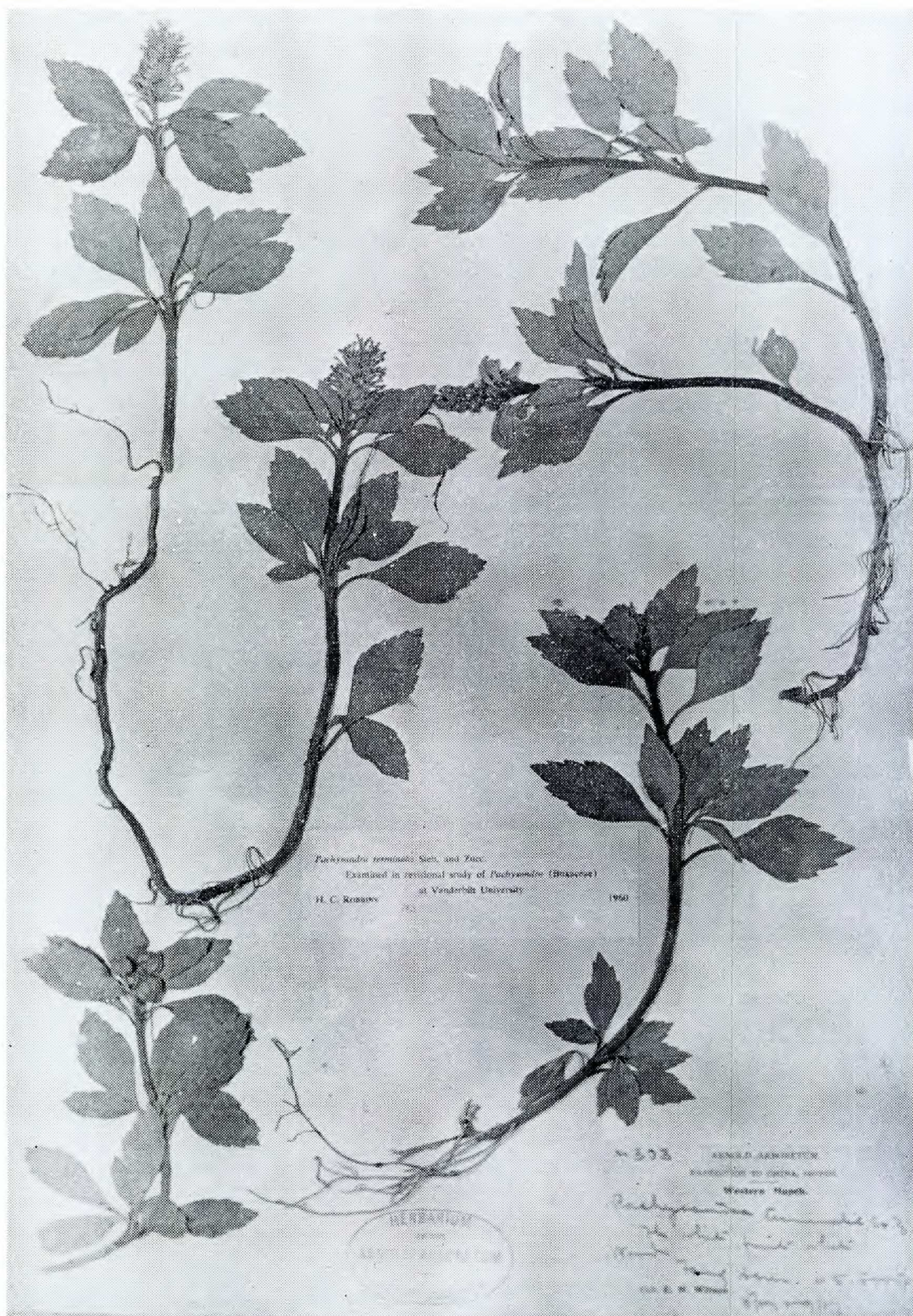


Fig. 2. *Pachysandra terminalis* Sieb. & Zucc.

acute to obtuse, concave, ciliate bracteoles, broadly ovate in outline, coriaceous in texture; calyx of 4 broadly ovate, concave, obtuse, ciliate

sepals 2.5-4 mm long, 2-2.5 mm wide; stamens 5-7 mm long with compressed clavate filaments 4-6 mm long, the linear or ovate, appendaged anthers 1.5-2 mm long, 1-1.5 mm wide becoming recurved after dehiscence. Pistillate flowers long-pedicellate, axillary to small reduced foliage leaves, the pedicel with many triangular to lanceolate, imbricate bracts. Gynoecium 2-carpellate, bilobed, the ovary 1-2 mm long, 1-1.5 mm in diameter; styles 2, divergent above, each 3.5-4.5 mm long, 0.5-1 mm broad, tapering upwards to a more or less blunt apex, stigmatic along the upper one-third. Fruit baccate, white and pulpy when fresh, bilobed, 6-7 mm long, 4-5 mm in diameter. Seeds 4-6 mm long, 2-3 mm broad, glossy brown to black in color, trigonal, apparently ecarunculate.

Abundant in deciduous woods at elevations between 3000 and 8000 feet; mountainous regions of northern Japan and north central China. (Map 1). Cultivated widely as an introduced ornamental in the cooler temperate regions of North America and Europe.

JAPAN: Honshu: at the foot of Mount Fugiyama, ex Herb. Lugd. Bat. (L); Sendai, July 1915, *Ken* (TI); in front of Buddhist temple, Gongen, Hakone, 20 May 1926, *Muramatsu* (TI); suburban area of Akita, 17 April 1928, *Muramatsu* (TI); Nikko in Shimotsuke, 19 May 1952, *Kubota*, distributed under no. 513, National Science Museum, Tokyo (BH, E, G, L, MO, NY, PH, UC, US); Kyoto, 5 April 1937, *Ohwi* 9140 (GH, NA, UC); Mino Province, 25 May 1922, *Shiota* 3005 (A); Numazawa in Uzen, 27 April 1946, *Okuyama* (BH); Lake Ashinoko, Hakone in Sagami, 8 October 1951, *Togazi*, distributed under no 385 by National Science Museum, Tokyo (L); Sagami, Mt. Hakone, June 1906, no collector indicated (E); Sagami, 3 October 1934, *Shiota* 7947 (A); Sagami, Mt. Hakone, 20 May 1910, no collector indicated (US); Hakone, 26 May 1876, *Bisset* 844 (E); Sagami, Hakone, 24 March 1910, *Sakurai* (E); in forest, altitude about 1000 meters, Kanagawa, 9 April 1950, *Suzuki* (UC, US); Kanagawa, 25 September 1949, *Suzuki* (A); Sagami, Mt. Hakone, 26 June 1911, no collector indicated (LD); Yezo, Kakomi, 1862, *Blake* (YU-2 sheets).

HOKKAIDO: Ishikari Mountain Range, Moiwa Yama, 19 May 1930, *Akiyama* (TI); Sapporo, 26 May 1887, *Tokubuchi* (PH); Mount Soranuma near Sapporo, June 1932, *Akiyama* (NY); Maruyama near Sapporo, 4 May 1907, *Takeda* (K); Sounkyo, 26 May 1952, *McClatchie* 126a (US); abundant in moist woods, Kitami province, 1914, *Wilson* (A); Muroran, 24 August 1905, *Jack* (A); along road in undergrowth near Nikoro, 24 September 1929, *Dorsett and Morse* 1098 (A, GH, US); Hakodate, 1861, ex Herb horti bot. Petropolitani (FI, GH, L, M, NY, US); mountains northeast of Hakodate, 1853-1856, *Wright*, ex Herb. of the United States North Pacific Exploring Expedition (GH, US); summit of mountains northeast of Hakodate, in dense shade of trees and shrubs, 22 June 1855, *Wright* (L).

CHINA: SZECHWAN: District of Tchen-keou-tin, *Farges* 198 (BM); 1885-1888, *Henry* 6802a (BM); ex Herb. M. de Coincy, *Farges* (K).

HUPEH: Specimens without definite locality: 1885-1888, *Henry* 6802 (GH); 1885-1888, *Henry* 5331 (NY); 1885-1888, *Henry* 7836 (E, US); western Hupeh, *Wilson* 438 (NY); 1885-1888, *Henry* 4904 (E); woods, Fang Hsien, western Hupeh, alt. 5000-8000 feet, May-September 1907, *Wilson* 303 (A-2 sheets, E-2 sheets, GH, US).

KANSU: Alpine woods above Chago, very common, 7000 feet, 6 May 1914, *Farrer* and *Purdom* 48 (E).

CHEKIANG: Mount Hsi-tienmu-shan, 14 May 1935, *Migo* (A- ex Lingnan Univ. Herb).

SHENSI: Kian-san, 4 August 1877, *Giraldi* 3504 (FI, K).

YUNNAN: 18 June 1887, *Delavay* 6389 (L); Yunnan-fu, June 1908, native collector (L).

*Pachysandra terminalis* is easily distinguished by the terminal position of the inflorescence and by the two-carpellate gynoecium. Other distinctive characters are: the elevated veins of the adaxial surface of the leaf blade; the smaller stigmatic area occupying only the distal one-third of the style branch; the presence of a coriaceous bract and two bracteoles subtending each staminate flower; and the elongate, multi-bracteate pedicel of the pistillate flowers. The baccate fruits are also unique.

According to information from herbarium labels, the white, berry-like fruits of *Pachysandra terminalis* are eaten by the natives in Japan and China. They have been described as having a decidedly sweet taste.

Siebold and Zuccarini, in their original description of *Pachysandra terminalis* in 1845, did not designate a nomenclatural type. I have thus selected a sheet from Zuccarini's Herbarium, now preserved at the Botanische Staatssammlung, Munich, to serve as lectotype. The following inscription, apparently in Zuccarini's handwriting, is found on the sheet: "Legit in Japonia, Communicavit de Siebold, anno 1842, *Pachysandra terminalis* S. & A." Four leafy axes, probably all from a single clone, comprise the sheet. One bears the number 3257 which is assumed to be the collection number. The following is good indirect evidence that this sheet was among the original material which served as the basis for the original description: First, these specimens are from Zuccarini's Herbarium; second, the determination was made in cooperation with Siebold; and third, the sheet bears the date 1842 which is three years prior to the date of publication of the original description of the species.

Comparison of specimens of *Pachysandra terminalis* from China with those from Japan showed no outstanding morphological differences. Although the leaves of the Chinese plants were generally smaller and the blades more deltoid and serrate than those from Japan, no taxonomic significance was attached to these differences.

*Pachysandra terminalis* has been used quite extensively as an orna-

mental since its introduction into the United States in the 1800's. The glossy evergreen leaves, its low creeping growth habit, and its extreme tolerance to shade make it an attractive ground cover, especially in shady places where grass is difficult to establish. It is also easily propagated from cuttings of both aerial stems and rootstocks.

Two specimens of the horticultural ornamental, *Pachysandra terminalis* Sieb. & Zucc. var. *variegata* Manning, were examined during the course of this study. These were leafy stems bearing neither flowers nor fruits. They were collected by Boom and bear the Lund Herbarium numbers 11996 and 14844, respectively. The leaves of the specimens are small, 3-5 cm long and 1-2 cm wide and the teeth are acute. Ivory white areas, confined chiefly to the margins, give a variegated appearance to the leaves. Although the original source from which the variegated material appeared is unknown, it is probably of clonal origin.

Following the International Code of Nomenclature for Cultivated Plants (Utrecht: Regnum Vegetabile, 1961), Article 15b, it seems best to refer to this cultivar as *Pachysandra terminalis* 'variegata', instead of *Pachysandra terminalis* var. *variegata*.

3. PACHYSANDRA AXILLARIS Franch., *Plantae Delavay*. 26: 135. 1889. "Yunnan, in silva Ta-long-tan, prope Tapintze, alt. 1800 m; 3 Mart. (Delavay, n. 1931)." (Type—P, photograph examined)

Erect suffrutescent subshrub, 3-4 dm in height, with a ligneous, rhizomatous rootstock, Aerial stems apparently annual, branching at the base, subterete, striate, 2-4 mm in diameter, stramineous when dried, hispidulous, the short stiff trichomes increasing in length and number upward to the distinctly petiolate leaves. Leaves (4-) 6-7 (-12) in number distributed at intervals of 1-3 cm along the upper half of the stem; blades submembranous to papyraceous, ovate to oblong-ovate, penninerved, 6-10 cm long, 3-6 cm wide, the basal  $\frac{1}{4}$  to  $\frac{1}{3}$  entire, truncate to subcordate at the base, the apical  $\frac{2}{3}$  to  $\frac{3}{4}$  crenate-serrate to serrate-dentate, acute to acuminate at the apex, the upper surface dark green and strigose with 3-4-celled, whitish trichomes becoming longer and more abundant near the margin, the midrib and laterals prominent but not elevated, the lower surface pale green and puberulous, the trichomes more abundant on the veins and margin, the midrib and laterals prominent and elevated, the margin ciliate; petioles noncanaliculate, puberulent, 2-4 cm long. Inflorescences axillary to foliage leaves, short-cylindric or globose, erect, each with (5-) 6-8 (-12) loosely arranged staminate flowers above the 1-3 pistillate flowers. Staminate flowers each subtended by a single ciliate, pubescent, triangular bract 1.5-2 mm long, 1 mm wide at the base, acute at the apex; calyx of 2 ovate, obtuse, ciliate, keeled outer sepals, 1.5-2.5 mm long, 1-1.5 mm wide and 2 broadly ovate, obtuse, ciliate inner sepals 2.5-3.5 mm long, 2-2.5 mm wide; stamens (5-) 7-9 (-12) mm long, 3-4 times the length of the sepals, with compressed-clavate filaments 5-8 mm long, the rotund to



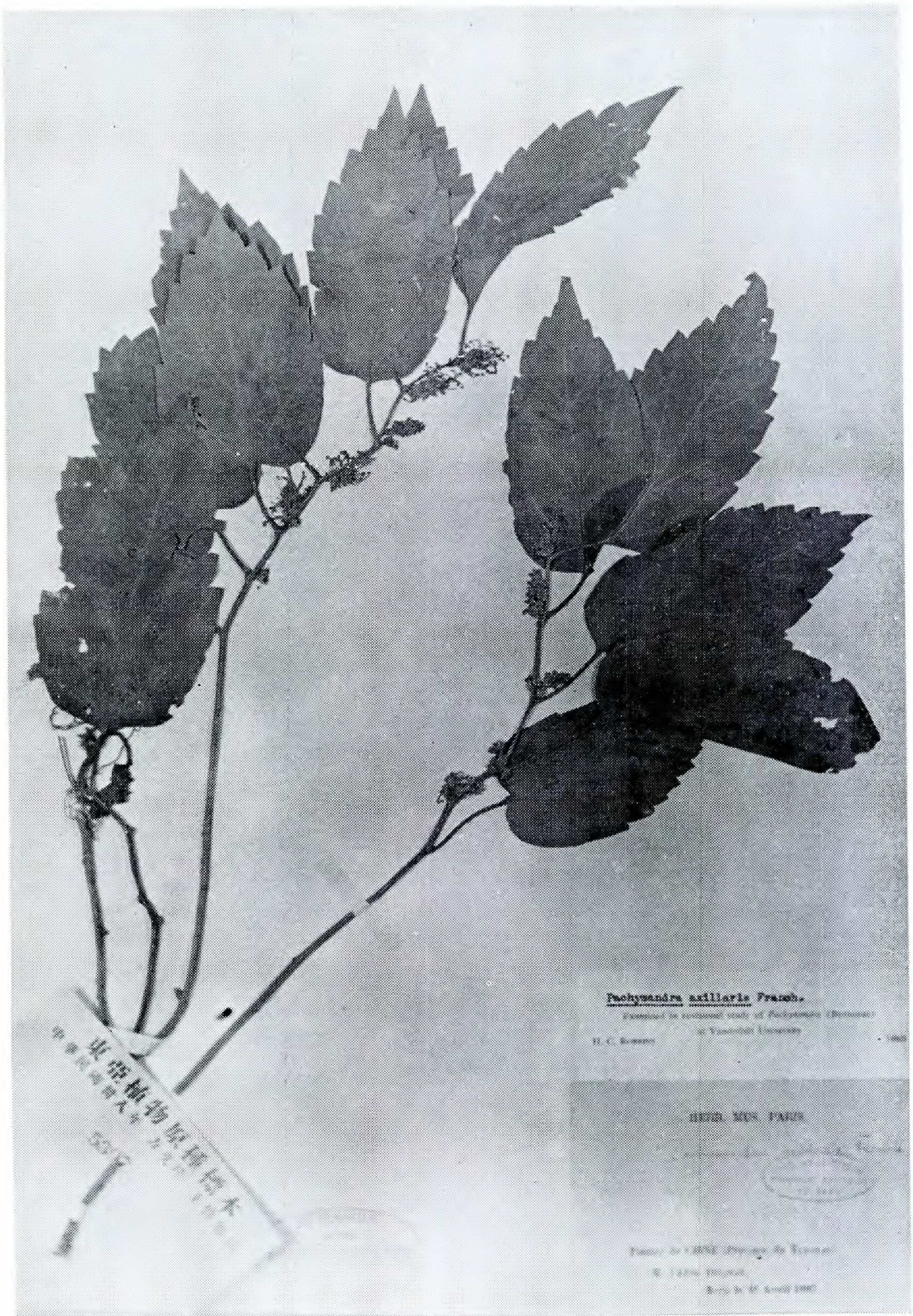


Fig. 3. *Pachysandra axillaris* Franch.

elongate, nonapiculate anthers, 1-1.5 mm long, 1 mm wide. Pistillate flowers each subtended by 13-14 bracts, the basal one pubescent, 1.5-2

mm long, 1-1.5 mm wide at the base, with a thickened midrib, the succeeding 6, ovate, acuminate, 2-2.5 mm long, 1-1.5 mm wide, the upper 6-7, elliptic, ciliate, 2.5-3.5 mm long, 1-1.5 mm wide. Gynoecium 3-carpellate; styles 3, elongate, slightly divergent above, becoming strongly recurved in fruit, 4-11 mm long, the linear, sulcate stigma occupying the entire length of the style. Fruit capsular, yellowish brown to black when dry, trilobed, 6-7 mm long, to 7 mm in diameter. Seeds 4.5-5 mm long, 2.5-3 mm broad, glossy dark brown in color, trigonal, ecarunculate.

Known only from Yunnan, China where it occurs on wooded slopes of ravines and at the margins of thickets near streams at altitudes ranging from 7,200 to 10,000 feet. (Map 1).

CHINA: Yunnan. Without specific locality, no date given, *Delavay* (F, GH); Cool and shady places in gorges of Tsang-chan above Tali at 2300 meters altitude, 19 April 1887, *Delavay* 2607 (A); ex Herbar de Pitard-Briau, no date given, *Delavay* (BM, E, G, GH-2 sheets); precise locality unknown, 4 September 1890, *Delavay* (E, GH, K, NY); Woods of Talong-tan near Tapintze, 10 November 1887, *Delavay* (E, K, NY); precise locality not given, 1 April 1889, *Delavay* (E, GH, NY); precise locality not given, 10 October 1889, *Delavay* (BM, NY); Bois de Talong-tan, pres Tapintze, 24 March 1890, *Delavay* (E); without precise locality, 28 June 1890, *Delavay* (G, GH, NY); Steep and wooded slopes of a ravine of a mountain near the College, vicinity of Yunnansen, 3 November 1899, *Bodinier* 18D (E); "Environs de Yunnan-sen", 3 November 1896, *Bodinier and Ducloux* 18 (GH); Yunnanfu, *Ducloux* 308 (E); at foot of cliff one-half way up mountain at La Kou, 2400 meters, November 1910, *Maire* 3907B (LA, NY, UC); *Maire* 225 (GH); *Maire* 304 (GH); cool and shady places in gorges of Tsong-chan above Tali, altitude 2300 meters, 19 April 1887, *Delavay* 2607 (GH); north of Yunnanfu, 10 March 1914, *Schneider* 322 (G); Salwin Valley, Lat. 28° N., 10,000 feet altitude, in thickets by streams, May 1918, *Forrest* 16338 (E, K); at the foot of cliffs, April 19—, *Maire* 238 (BM, E); vicinity of Yunnansen, no date given, *Maire* 318 (BM, E); Tsongchan, *Ducloux* 3610 (BM, E); western flanks of Mt. Tali Range, lat. 25° 40' N., margins of thickets, no date given, *Forrest* 15529 (BM, E); Siao-long-tan, no date given, *Maire* 7154 (BM).

Most of the material examined in this study was collected by Delavay, a French missionary collector, during the years 1887-1890 in the vicinity of Tapintze northeast of Tali Lake in Western Yunnan. In this area, the species grows at altitudes of 7000-9000 feet on steep and wooded slopes of ravines and at the margins of thickets near streams.

Taxonomically, specimens of *Pachysandra axillaris* have been confused most frequently with those of the *P. stylosa* complex, probably because of the axillary position of the inflorescences which they have in common. The two groups may be separated on the basis of certain characters that are chiefly vegetative but nevertheless constant. Plants of

*P. axillaris* have regularly dentate or distinctly crenate to serrate leaves, while those of the *P. stylosa* complex are only sparsely dentate to subentire. The leaves of *P. axillaris* specimens are papyraceous or parchment-like to submembranaceous in texture while those of *P. stylosa* are subcoriaceous to coriaceous. The leaf blades are usually truncate or subcordate in *P. axillaris*, while in *P. stylosa*, the blades, although highly variable, are usually rounded to obtuse or oblique, more commonly tapering into the petiole. Another character distinguishing *P. axillaris* from *P. stylosa* is the presence in the former of hairs on the upper surface of the leaves, concentrated in a zone on or near the margin, thus creating a ciliate or pubescent submarginal condition. The upper leaf surface of *P. stylosa* is glabrous, the margin eciliate. The pistillate flowers of *P. axillaris* are small, always sessile, with the style barely exerted beyond the calyx. The pistillate flowers of the *P. stylosa* complex are nearly always larger, subsessile to distinctly pedicellate, with long exerted styles.

There should be no difficulty in distinguishing *Pachysandra axillaris* from either *P. procumbens* or *P. terminalis* and little cause for confusing *P. axillaris* and the several varieties of *P. stylosa* with the possible exception of variety *tricarpa*. Although *P. stylosa* var. *tricarpa* shares the small, globose inflorescences in which the axis is equal to or less than the length of the filament, it may be clearly distinguished from *P. axillaris* by any one of the several characteristics enumerated below. There are usually 6-8 staminate flowers per inflorescence in *P. axillaris*. In *P. stylosa* var. *tricarpa* the number varies from 3-6. The leaf blades of *P. axillaris* are truncate to subcordate at the base while in *P. stylosa* var. *tricarpa* the base is rounded or oblique. The margin of the apical portion of the leaves is regularly dentate or serrate to crenate in *P. axillaris*. It is sparsely dentate in *P. stylosa* var. *tricarpa*. The upper surface of the leaf in *P. stylosa* var. *tricarpa* is glabrate and the margin eciliate. In *P. axillaris* the upper surface is strigose and the margin is ciliate. The petioles of *P. stylosa* var. *tricarpa* are canaliculate. Those of *P. axillaris* are noncanaliculate. *P. axillaris* is known only from central and western Yunnan. *P. stylosa* var. *tricarpa* occurs only in Sikang and Szechwan provinces.

#### 4. PACHYSANDRA STYLOSA Dunn

The systematic treatment of the *Pachysandra stylosa* complex has proved to be problematical for various reasons. Lack of a sufficient number of representative specimens has made it difficult to provide a true picture of variation. Collections of *Pachysandra* from 52 herbaria have yielded approximately 65 sheets of *Pachysandra stylosa*, these representing less than twenty different stations. Many of the specimens were in poor condition or otherwise quite inadequate because of their fragmented condition. Of the available specimens, only 28 provided good floral structures. It has been necessary, therefore, to rely heavily upon

vegetative characters in defining the species on a morphological basis.

Interpretation of the *Pachysandra stylosa* complex from a geographical standpoint was hampered to a considerable degree both by the lack of sufficient collection data for some specimens and the obscure Chinese place names given as collection sites. Several of these names could not be located on present day maps because they were either English or French corruptions of the Chinese or were names of obscure villages or mountains.

The brief original description of *Pachysandra stylosa*, notably vague as to detail, in many ways is quite similar to that of *P. axillaris*. This, in addition to the atypical nature of the type specimen, has presented difficulty in the establishment of a clear concept of the taxon, *P. stylosa*.

The specimen upon which Dunn based the original description differs from the other specimens which I have associated with *Pachysandra stylosa*, particularly with respect to the height of the plant, size of the leaves and nature of the leaf margin. The plant from which the type was collected was a tree 6 feet tall, according to information on the herbarium sheet bearing it. Other representatives of this taxon are subshrubs that rarely exceed 14 inches in height. The leaf blades of the type specimen are 5-6 inches long, whereas those of the remaining *Pachysandra stylosa* specimens average 3-4 inches in length. The leaf margins of the type specimen are entire except for minute mucra toward the apex. In other specimens of the complex, a few leaves may be entire-margined but in no case are all the leaves entire. While the type specimen has more than 20 staminate flowers per inflorescence, the other specimens usually have less than twelve and, in many cases, less than six per inflorescence.

Comparison of staminate flowers was necessarily limited to the number per inflorescence and to the structure of the calyx, since no stamens were present on the type specimen. Use of the pedicellate nature of the pistillate flowers as a distinguishing character by Dunn is questioned by the present author because it has been found that, in some cases, even in *Pachysandra axillaris* and *P. procumbens*, a pistillate flower may become slightly pedicellate at maturity or in the process of fruit formation. The decidedly pedicellate nature of the pistillate flowers of the type specimen may be due to similar elongation following anthesis.

Specimens of *Pachysandra stylosa* frequently have been incorrectly determined as *P. axillaris*, apparently on the basis of the axillary position of the inflorescence alone. Many of these determinations were corrected by Handel-Mazzetti as indicated by his annotations of herbarium material. Apparently he has been the only one to recognize and annotate any specimens as *Pachysandra stylosa* since Dunn published the original description in 1908.

It has become necessary to broaden the original concept of *Pachysandra stylosa* due to the wide variability of the specimens which must

be associated with it. In this respect, the present author is in agreement with Handel-Mazzetti, who recognized specimens possessing a wide range of morphological variation as *P. stylosa*.

The *Pachysandra stylosa* complex, interpreted in a broad sense in this investigation, is highly variable, especially with respect to vegetative characters. This is not altogether surprising since the range of the species is so vast, covering areas exhibiting tremendous extremes in topography. Plants belonging to the *P. stylosa* complex are distinguished from other members of the genus by a combination of the following characteristics: inflorescences located in the axils of foliage leaves; leaf blades subentire or sparsely dentate, rarely entire, the base obtuse to oblique, the upper leaf surface glabrous, the margin eciliate; anthers usually apiculate not usually reflexed at anthesis; styles usually well-exserted at anthesis.

During the course of this investigation, herbarium specimens possessing these characteristics were brought together into one group. This assemblage was designated as the *Pachysandra stylosa* complex. In an effort to determine whether particular variations were constant and whether they segregated out on a geographical basis, the specimens were sorted into groups based upon morphological similarities and differences.

The resulting groups were then subjected to critical analyses in an attempt to determine constant characters that would serve to distinguish them. This included comparison of leaf size, length *vs.* width, shape and texture of blades; type and distribution of hairs on the leaves and stems; the form of the bracts and sepals of both staminate and pistillate flowers, including length *vs.* width and vascularization. Six morphological groups, each distinct with respect to certain characters and, in general, exhibiting allopatric distribution, became evident as a result of this process.

It is problematical how these groups, each comprised of less than 20 specimens, should be treated taxonomically. The paucity of specimens, lack of complete collection data, incomplete biological data, lack of information concerning breeding systems all make an adequate taxonomic disposition extremely difficult.

One alternative, which does not seem entirely satisfactory, would be to treat the members of each group as variants of *Pachysandra stylosa* and to describe the variations exhibited by each specimen individually. Since there are so many minor variations among the representatives of each group, it is feared that such a recourse would only add to the already existing confusion.

Another approach would be to name and describe each assemblage as a variety of *Pachysandra stylosa*. In view of the relatively good degree of morphological and geographical discontinuity, this method has been used in the present treatment. Because of the small number of





Fig. 4. Holotype of *Pachysandra stylosa* Dunn var. *stylosa*.

Tze Chuk Hang, Central Fukien, Dunn, May 30th, 1905, Hong Kong Herb. No. 3514." (Type—HK3514; Duplicates of the type: GH, K—photograph examined).

Erect shrub, up to 2 meters (?) in height. Aerial stem simple or branched, puberulent under 10X magnification, striate, terete, 3-4 mm in diameter, becoming angular when dried. Leaf blades coriaceous, ovate or elliptic, acute at the apex, obtuse at the base, 12-16 cm long, 6-11 cm wide, penninerved, the veins glabrous, prominent and slightly elevated on the abaxial surface, prominent but depressed on the adaxial surface, the margin eciliate, entire or with only minute teeth toward the apex, the petiole puberulent, 3-5 cm long. Inflorescences axillary to foliage leaves, lax and drooping in position, 2.5-3.5 cm long, each with 15-20 staminate flowers above the 2-4 pistillate flowers. Staminate flowers each subtended by a single, ciliate, broadly ovate bract 2.5-3 mm long, 2-2.5 mm wide at the base, acute at the apex; calyx of four elongate-ovate to oblong-obtuse, ciliate sepals 3.5-4 mm long, 2.5 mm wide, covered by numerous reddish brown spots. Pistillate flowers pedicellate, the puberulent pedicel 1.5-2 mm long, subtended by 10 bracts, the basal one elliptic to ovate, 1.5-2 mm long, 1.5 mm wide, the succeeding 4 elliptic to elongate ovate, reddish in color, 2.5-3.5 mm long, 2-2.5 mm wide, the upper 5, 4-5 mm long, 2.5 mm broad, oblong, obtuse, concave, ciliate, beset with reddish brown spots. Gynoecium 3-carpellate, styles 3, linear, 7-9 mm long, slightly divergent, stigmatic surface introrse, sulcate, occupying the entire length of the style.

Known only from the type locality. Deep gorge at Tze Chuk Hang, Central Fukien, China. (Map 1).

CHINA: Fukien. Deep gorge at Tze Chuk Hang, *Dunn 1439* (HK—Holotype, GH—Isotype, K—Isotype, photograph examined).

No specimen examined during the course of this study was considered sufficiently similar to the type to warrant associating it with this variety. *Pachysandra stylosa* var. *stylosa* is therefore represented only by those specimens upon which Dunn based the original description of the species. These specimens were collected in a deep gorge in central Fukien by native collectors during Dunn's expedition to that province in 1905. As far as I have been able to determine, only 3 specimens are now in existence. Two of these, the type and an isotype, have been examined during the course of this study. A photograph of the second isotype has also been examined. These specimens leave much to be desired in that they are only portions of a plant and are in relatively poor condition. The leaves are broken and portions of them are missing. No stamens are present. The calyces of the staminate flowers, however, are intact. According to the collection data accompanying the herbarium sheets, the plant from which the specimens were collected was a tree 6 feet tall. This is almost 6 times the height of the tallest plants in the other varieties. For this reason, it is suggested that an error may exist in the collection data.





Fig. 5. *Pachysandra stylosa* Dunn var. *reflexa* var. nov.

The reputed size of the plants, plus the entire-margined leaves and the elongate, drooping, inflorescences bearing numerous staminate flowers are characters that distinguish this variety.

4b. *PACHYSANDRA STYLOSA* Dunn var. **reflexa** Robbins var. nov.

Laminae oblongo-ellipticae, 2.5-3 plo longiores quam latae, crasse dentatae. Apices dentium ad latum vel ad basin laminae versi. Filamentum antherae cristis papillosis parvis terminatum.

Erect subshrub, 2.5-5 dm in height with a ligneous, rhizomatous rootstock. Aerial stem simple or sympodially branched, subterere, striate, becoming angular when dried, 3-5 mm in diameter, with short, stiff trichomes. Leaves 4-7 in number, blades coriaceous, oblong to elliptic, penninerved, 11-15 cm long, 4.5-5 cm wide, the basal 1/3 to 1/2 entire, the apical 1/2 to 2/3 toothed, the apices of the teeth directed laterally or toward the base of the blade, the upper surface dark green and glabrous, the midrib and laterals prominent and depressed, the lower surface pale green and glabrous, the midrib and laterals prominent and slightly elevated, the margin eciliate, recurved; petioles glabrate, 3-4 cm long. Inflorescences axillary to foliage leaves, globose to elongate, 1-1.5 cm long, sessile to short pedunculate, each with 10-14 staminate flowers above the 1-2 pistillate flowers. Staminate flowers each subtended by a single, ciliate, pubescent, ovate to subtriangular bract, 1.5 mm long, 1 mm wide at the base, acute at the apex; calyx of 4 broadly ovate concave, obtuse, ciliate sepals, the outer two 2.5-3 mm long, the inner two 3.5-4 mm long, 2-2.5 mm wide; stamens 7-9 mm long, 2.2-2.5 times the length of the sepals, anthers 1.5-2 mm long, nonapiculate but with a tuft of minute papillae at the apex (under magnification). Pistillate flowers shortly pedicellate, each subtended by 10-11 bracts, the basal one broadly ovate to triangular, 1-1.5 mm long, 1 mm wide at the base with an acute apex, the succeeding 4-5 bracts ovate, acute, 1.5 mm long, 1 mm wide, with a prominent midrib, the upper 5 obtuse at the apex, 3 mm long, 1-1.5 mm broad, with a prominent midrib. Gynoecium 3-carpellate; styles 3, each 2 mm long, .5 mm broad, ovary 1 mm long. Fruits unknown.

Known only from the type locality, Yunnan; Mengtse. (Map 1).

CHINA: Yunnan: Mengtse, 6000 feet between Hsien Chen Kin and Tin Moko, *Henry 9959B* (US-Isotype, MO-Isotype, NY-Isotype, E-Holotype, K-Isotype).

*Pachysandra stylosa* var. *reflexa* is distinguished by the oblong to elliptic leaf blades with the length 2.3-3 times the width and the conspicuous lateral orientation of the apices of the teeth. Another distinctive feature of this variety is the presence of small tufts of papillae at the apices of the anthers.

Although the single collection of only 6 specimens leaves much to be desired, this element is so clearly and conspicuously marked morphologically by the reflexed teeth and the length *vs.* width ratio of the

blade that it would appear to deserve taxonomic designation. It may be argued that the description of the new variety on the basis of a single collection leaves everything to be desired from a biological point of view, yet I have been unable to equate or to reconcile the element represented with any other taxon. After careful consideration of all evidence, it appears that the logical thing to do is to establish a new variety.

4c. *PACHYSANDRA STYLOSA* Dunn var. **tomentosa** Robbins, var. nov.

Folia subtus manifeste tomentosa, pili longi multicellulares. Sepala exteriora lateralia florum staminatorum ad apicem crista pilorum multicellularium ad apicem.

Erect subshrub, 2-2.5 dm in height, with a ligneous, rhizomatous rootstock. Aerial stem terete, woody, 2.5-3 mm in diameter, simple or branching at the base, striate with numerous short stiff trichomes, increasing in number toward the summit. Leaves penninerved, 5-7 in number along the upper half of the aerial stem, decidedly coriaceous, the ovate to almost elliptic blades 7-10 cm long, 3.5-6 cm wide, dark green and glabrous above, pale green and densely woolly or tomentose beneath, the trichomes long and multicellular, each composed of elongate cells up to 8 in number, the veins prominent but depressed on the upper surface, the margin eciliate, recurved, the basal portion obtuse, entire, becoming subentire to sparsely dentate toward the apex, the teeth, when present, broad but not deeply cut, the petiole canaliculate, hispid, 2-4 cm long. Inflorescences axillary to foliage leaves, subsessile, 2-3 cm. long, each composed of 15-16 staminate above the pistillate flowers. Staminate flowers each subtended by a single short, subtriangular bract, acute at the apex and densely pubescent; calyx of 4 sepals, the outer two ovate, somewhat keeled, 2.5 mm long, 1.5 mm wide, with trichomes along the midrib and aggregated in a tuft at the apex, the inner sepals oblong to oblong-ovate, concave, 2.5 mm long, 2-2.5 mm wide at the base; stamens 6-7 mm long, twice the length of the sepals, with anthers 1.5-2 mm long, the connective projecting as an appendage. Pistillate flowers short-pedicellate, the pedicel multibracteate, the basal bract subtriangular, 1.5 mm long, 1 mm wide at the base, the succeeding 4-5 bracts elongate-ovate to lanceolate, 1.5-2 mm long with long trichomes on the outer surface, the upper 6-7 bracts elongate ovate to lanceolate, ciliate, concave, 2.5-3 mm long, 2-2.5 mm wide. Gynoecium 3-carpellate, styles 3, 3-6 mm long, slightly recurved, exerted beyond the calyx.

Known only from Yunnan, China.

CHINA: Yunnan. Lunan, date of collection not give, *Henry 9959A* (A—Holotype, E, MO—Isotype); Milet, date of collection not given, *Henry 9959* (MO, NY); Wenshan Hsien, woodland, altitude 2000 meters, 13 January 1933, *Tsai 51514* (A); Wenshan Hsien, on roadside, altitude 1600 meters, *Tsai 51605* (A).

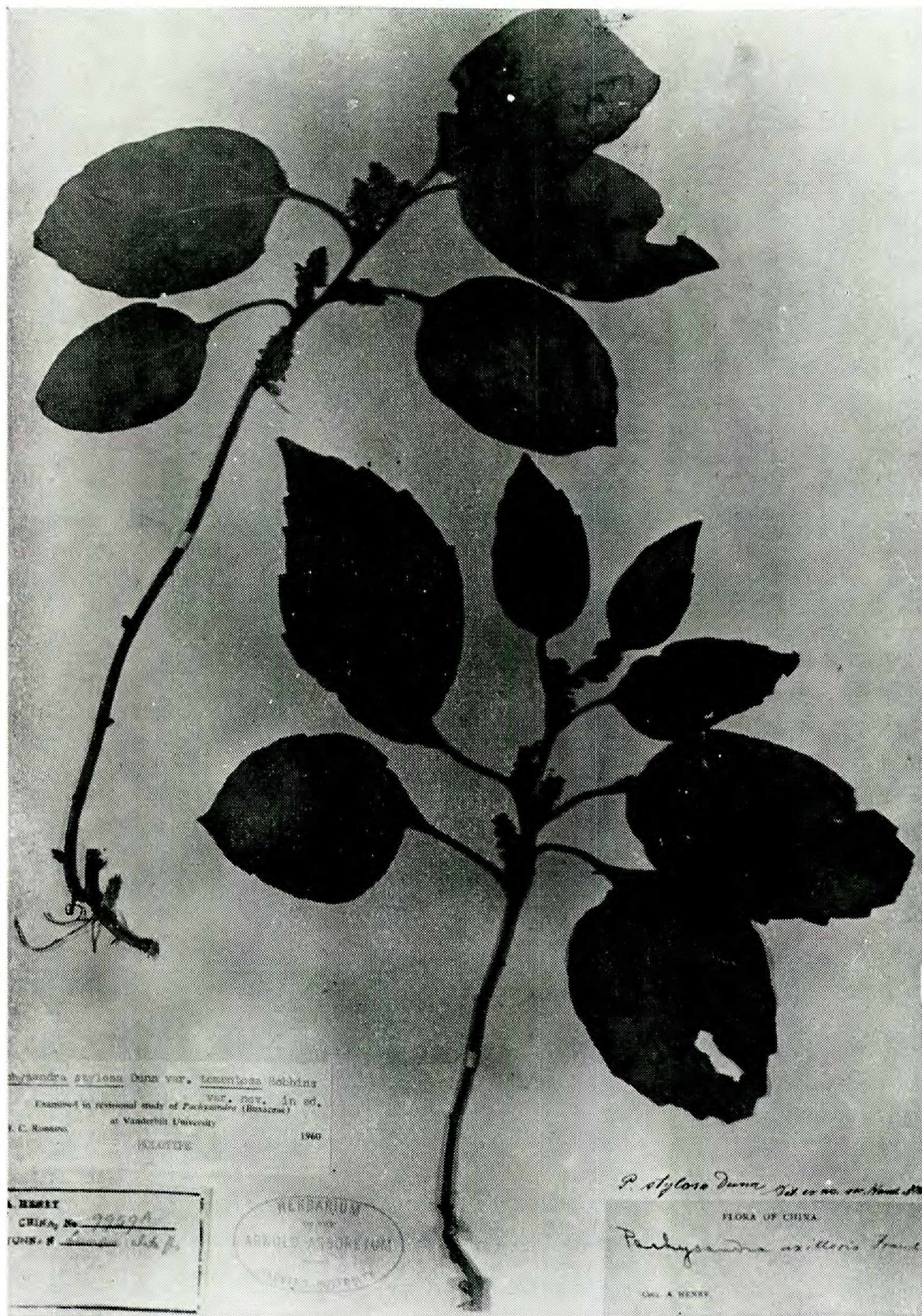


Fig. 6. Holotype of *Pachysandra stylosa* Dunn var. *tomentosa* var. nov.

The morphological features by which *Pachysandra stylosa* var. *tomentosa* may be distinguished include: the conspicuously tomentose vesture of the lower leaf surfaces consisting of long, densely arranged,

multicellular hairs and the presence of a tuft of multicellular trichomes at the apex of the lateral, outer sepals of the staminate flowers.

As indicated in the citation of specimens examined, this variety has a very limited known distribution. Only six specimens were available for this study. These were collected in Yunnan, an area noted for a high degree of endemism.

4d. *PACHYSANDRA STYLOSA* Dunn var. **kouytchensis** (Léveillé) Robbins, comb. nov.

*Pachysandra axillaris* Franch. var. *kouytchensis* Léveillé. Fl. Kouytchéou p. 166. 1914.

Erect subshrub, 2-5 dm in height, with a ligneous, rhizomatous rootstock. Aerial stem ligneous, sympodially branched, terete, becoming angular when dried, 3-4 mm in diameter, dark reddish brown in color toward the summit, densely hairy with short stiff trichomes. Leaves 5-7 in number, blades submembranaceous to papyraceous, broadly ovate, sometimes obovate or spatulate, trinerved, veiny, (5-) 7-8 (-11) cm. long, (3-) 5-6 cm. wide, the basal portion obtuse, sometimes cuneate, entire, the apical portion slightly dentate (sometimes distinctly dentate), the teeth minutely apiculate, the upper surface grayish olive-green and glabrous, the lower surface pale green with grayish, velvety pubescence, becoming glabrate in age, the lateral and tertiary veins prominent, and covered by soft, brown hair, the margin eciliate; petioles densely pubescent, 3.5-4 cm long,  $1/3-1/2$  the length of the blade, reddish brown in color when dried. Inflorescences axillary to foliage leaves, sessile, 2.5-3 cm long, each with 11-15 staminate flowers above the 1-3 pistillate flowers. Staminate flowers each subtended by a single, ciliate, pubescent, reddish, broadly ovate bract, 2-2.5 mm long, 1.5-2 mm wide at the base, acute at the apex; calyx of 4 subequal, oblong-ovate, concave, obtuse sepals, 3.5-4 mm long, 2-2.5 mm wide, each with reddish spots and a prominent midrib; stamens 9-10 mm long, the sagittate anthers 2.5 mm long, 1.5 mm wide at the base, apiculate, slightly deflexed. Pistillate flowers each subtended by 8-10 bracts, the basal one broadly ovate, 1-1.5 mm long, 1 mm wide at the base, acute at the apex, the succeeding 2-3, lanceolate, acute, ciliate, 3.5-4 mm long, 2-2.5 mm broad, the upper 5-6, lanceolate, ciliate, acute, concave, 4.5-5 mm long, 1.5-2 mm broad, each with 6-8 veins from the base, midrib prominent and pubescent. Gynoecium 3-carpellate; style 3, linear, nearly distinct, 6-7 mm long, stigma introrse, sulcate, occupying the entire inner surface of the style branch.

CHINA: KWEICHOW. Tsin-gay, date unknown, *Bodinier* (E—Holotype); vicinity of Kouyang, mountain at the College, 20 March 1898, *Chaffanjan* 2186 (E); Kouyang, Tinfa, May 1902, *Cavalerie* 1333 (E-3 sheets, K); Houangtsaopa, 1900-1920, *Cavalerie* 7956 (E, K, UC). SZECHWAN. Kuan-hsien, 28 February 1937, *Chien* 5828 (E); Kuan-hsien, 4

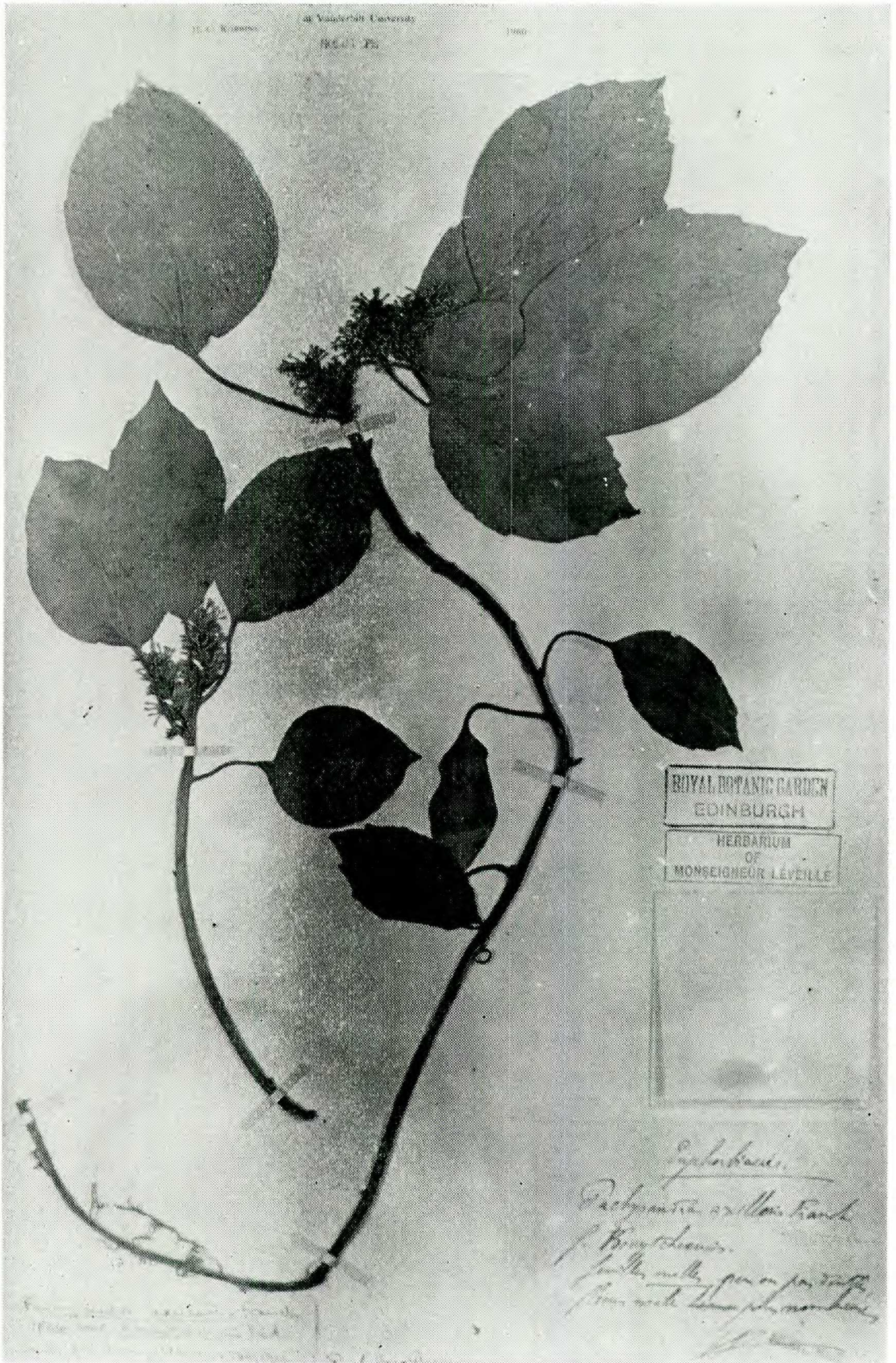


Fig. 7. Holotype of *Pachysandra stylosa* Dunn var. *kouytchensis* (Levl.) Robbins comb. nov.

April 1938, *Fan and Class 137* (A); Kuan-hsien, 6 July 1937, *Chien 5803* (E).

This taxon, first described as *Pachysandra axillaris* var. *kouytchensis* by Leveillé, subsequently was placed into synonymy with *Pachysandra stylosa* by Handel-Mazzetti. In the present work, variety *kouytchensis* of *P. axillaris* is treated as a variety of *P. stylosa*.

*Pachysandra stylosa* var. *kouytchensis*, although represented by rather variable specimens, may be distinguished on the basis of a combination of the following characters: the conspicuously long stamens with sagittate anthers; the elongate inflorescences and the lanceolate bracts of the pistillate flowers; by the submembranous, veiny leaves, usually with soft, grayish green indument on the lower surface.

The shape of the leaf blade is often highly variable. The leaf blades of one specimen, *Chaffanjan 2186* (E), are oblanceolate to obovate-spatulate in outline. Four fragmentary specimens, collected by *Cavalerie 1333*, have highly variable leaves. In some cases there are broadly ovate and spatulate leaves on the same plant. Several dried fruits are present on two of the specimens. These are reddish brown in color and appear to have been pulpy in texture before drying. The herbarium label states that the fruits are eaten by natives.

4e. *PACHYSANDRA STYLOSA* Dunn var. ***tricarpa*** (Hayata) Robbins comb. nov.

*Pachysandra axillaris* Franch. var. *tricarpa* Hayata. Ic. Pl. Formosa. 3: 171-172. 1913.

*Pachysandra Borinieri* Lev., Fedde Repert. 12: 187. 1913.

Erect subshrub 2-3 dm in height with a terete woody, rhizomatous rootstock. Aerial stem simple, sometimes branching sympodially near the base, woody, terete, glabrate. Leaves 6-7 in number clustered near the summit of the stem, the subcoriaceous, ovate-oblong or elongate-oblong blades 6-8 cm long, 3-4 cm wide, dark green in color and glabrate above, pale green and glabrate below, prominently penninerved, the lower surface with midrib and laterals elevated, the margin eciliate, involute, the basal portion rounded or more or less oblique, entire, becoming weakly dentate toward the acute, abruptly acuminate or caudate apex, the petiole canaliculate, 1.5-3 cm long. Inflorescences small, globose, axillary to foliage leaves, short-pedunculate to sessile, 0.8-1.5 cm long, each with 3-6 staminate flowers above the 1-2 pistillate flowers. Staminate flowers each subtended by a single, subtriangular pubescent bract 1-2 mm long, 0.75-1.5 mm wide at the base, the margin ciliate, the apex acute; calyx of 4 decussately arranged, oblong, obtuse, concave sepals, each 2-3.5 mm long, 1-2.5 mm wide, obscurely 5-nerved; stamens 5-9 mm long, the apiculate anthers 1.5-2 mm long, 1-1.25 mm wide. Pistillate flowers sessile, 5-6 mm long, subtended by 8-10 bracts, the basal one elongate, ovate, with an acute apex, the succeeding

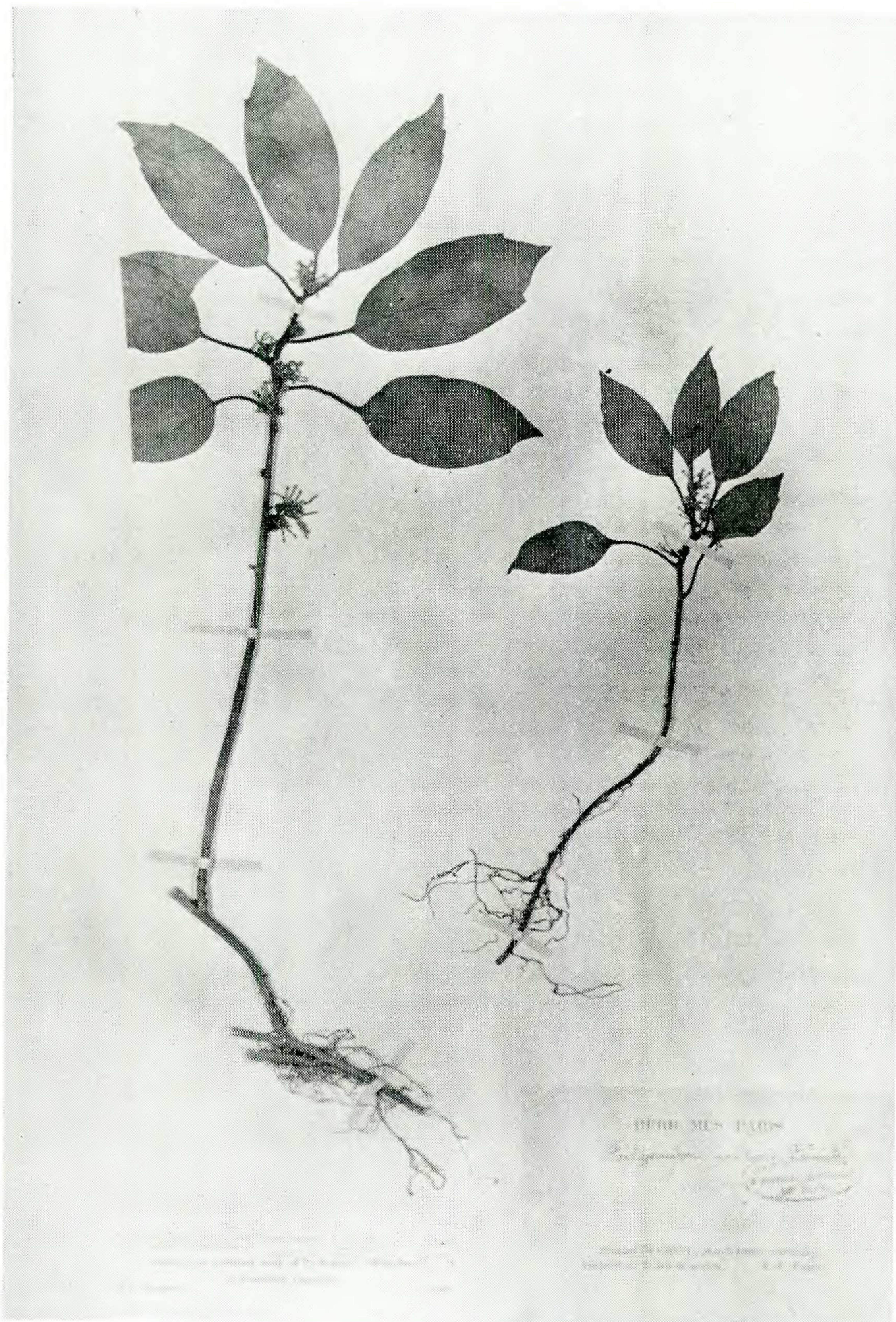


Fig. 8. *Pachysandra stylosa* Dunn var. *tricarpa* (Hayata) Robbins comb. nov.



3-4 bracts, subequal, 1.5-2 mm long, 1-1.5 mm broad; the upper 4-5 bracts, elongate ovate, sometimes obovate, 4 mm long, 2 mm wide, concave, ciliate, the apex obtuse. Gynoecium 3-carpellate, styles 3, linear, 3.5-4 mm long, slightly recurved. Fruits pedicellate, capsular, 6 mm long, 7 mm in diameter. Seeds brown, 5 mm long, 3 mm wide.

Found in western and northeastern Szechwan, Sikang and Yunnan, China and Taiwan. (Map 1).

CHINA: Specimens without precise locality: Valley of Kiao-me-ti, alt. 3000 m, April 1913, *Maire* (E—2 sheets, G). SZECHWAN. Mt. Omei, 21 April 1932, *Yu* 479 (GH); Mt. Omei, 14 April 1940, *Sun* 1531 (US); Mt. Omei, October 1937, *Liu* 1455 (A); *Omei Shan*, 21 August 1938, *Chiao* and *Fan* 814 (A); Mt. Omei, 6 May 1940, *Sun* 1859 (US); Mt. Omei, under woods, altitude 2400 meters, 21 April 1932, *Yu* 481 (GH); Tchen-keou-tu (Chengkow?), *Farges* (A, BM, E, K, NY). TAIWAN. Tonkarankei, 16 April 1910, *Mori* (US-Holotype, photograph examined). YUNNAN. "Mont entre Ma Kay et Se-tchong-hsien, a' tien den Kiao", 3 April 1887, *Bodinier* (E). SIKANG. Near Tachienlu at 9,000-13,500 feet, *Pratt* 796 (BM).

*Pachysandra stylosa* var. *tricarpa* is distinguished by the very small inflorescences, each usually consisting of less than six staminate flowers and with an axis shorter than the length of the stamens. Each pistillate flower is subtended by 8-10 bracts. The leaves are often long-acuminate or caudate.

This variety is most closely related to and most likely to be confused with *Pachysandra stylosa* var. *glaberrima* but differs from it primarily with respect to the number of staminate flowers and the number of bracts subtending the pistillate flowers. (See discussion of var. *glaberrima*).

Although originally described by Hayata as variety *tricarpa* of *Pachysandra axillaris*, the taxon is here transferred to *P. stylosa*. In making this transfer, it has been necessary to rely upon morphological evidence alone. Morphologically, variety *tricarpa* is more like *Pachysandra stylosa* than *P. axillaris*. The leaves are elliptic and sparsely dentate with eciliate margins and obtuse to oblique bases, characters, as has already been pointed out, by which *P. stylosa* and *P. axillaris* differ. It would appear that *P. axillaris* and *P. stylosa* var. *tricarpa* are too widely separated geographically for any genetic exchange to take place between them, whereas var. *tricarpa* is geographically close enough to other varieties of *P. stylosa* for such exchange to take place. (See Map 1).

4f. PACHYSANDRA STYLOSA Dunn var. GLABERRIMA Hand.-Mazz.  
Symb. Sinicae 7:236. 1929-1937. "Unter Strauchern in einem Graben bei Sanyingpan n. von Yunnanfu, 26°, Sandstein der wtp. St., 2400 m 14 III, 1914."

Erect subshrubs 1-3 dm in height with a terete woody, rhizomatous rootstock. Aerial stem terete, woody, 3 mm in diameter, simple or sym-

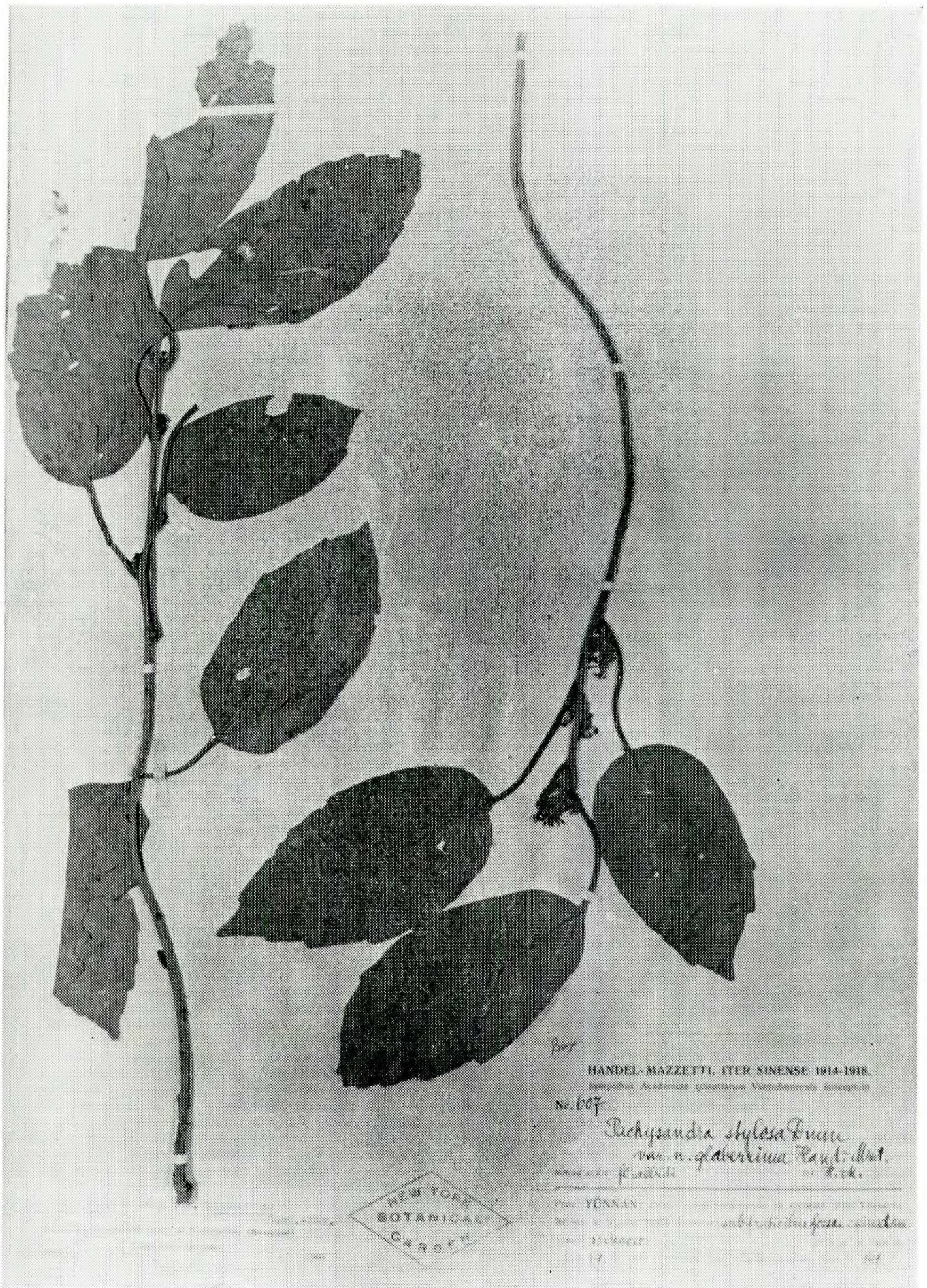


Fig. 9. Lectotype of *Pachysandra stylosa* Dunn var. *glaberrima* Hand.-Maz.

podially branched, glabrous to glabrate under magnification. Leaves 5-6 in number at the summit of the stem, subcoriaceous to coriaceous, the

elongate-ovate or elliptic-ovate blades 7-10 cm long, 3-5 cm wide, dark green and glabrous above, pale green and glabrous beneath, the mid-rib and lateral veins prominent, slightly elevated on the lower surface, terminating in apiculae at the margin, the margin eciliate, the basal portion rounded or obtuse, entire, becoming sparsely dentate toward the acute apex; the petioles canaliculate, glabrous, 3.5-4.5 cm long. Inflorescences axillary to foliage leaves, short-pedunculate to subsessile, 3-5 per shoot, 1-2 cm long, each composed of 6-10 staminate flowers above the 1-2 pistillate flowers. Staminate flowers each subtended by a single, ciliate, triangular bract, 2-2.5 mm long, 1.5-2.5 mm wide with an acute apex; calyx of 4 obtuse, concave, ciliate sepals, the outer two ovate and keeled, 3-4 mm long, 1.5-2 mm wide, the inner two broadly ovate, 3-3.5 mm long, 2-2.5 mm wide with approximately 7 nerves; stamens 5-8 mm long, 2.5 times the length of the sepals, with anthers 1.5-2 mm long, the connective projecting as an appendage. Pistillate flowers subsessile to sessile, 5-6 mm long, each subtended by 12-14 bracts, the basal one elongate ovate, 1.5 mm long, 1 mm wide, with an obtuse apex, the succeeding 5-6 subequal, 1.5-3 mm long, 1.5-2 mm broad, the upper 6-7, elongate-ovate, concave, ciliate, 3-3.5 mm long, 1.5-2 mm wide, with an obtuse or rounded apex. Gynoecium 3-carpellate; styles 3, reddish brown in color, recurved at the distal end, 4-7 mm long, 1-1.5 mm broad, usually 1.5-2 times the length of the sepals. Fruit reddish brown, short stipitate, 8-9 mm high, the persistent styles 11-12 mm long.

CHINA: YUNNAN. "Unter Strauchern in einem Graben n. von Yunnanfu, 26°, Sandstein der wtp. St., 2400 m., 14 III 1914, *Handel-Mazzetti* 607 (A-2 sheets, E, NY-Lectotype, US); Sanyingpan, 14 March 1914, *Schneider* 396 (A). KWEICHOW. Weining, in open hillsides, 17 October 1930, *Tsiang* 9174 (A, BM, E, G); Langtai, on open hillsides, 5 November 1930, *Tsiang* 9539 (NY, US). SZECHWAN. Without definite locality, 1885-88, *Henry* 7529 (BM, GH); Without precise locality, 1885-88, *Henry* 5589 (US); Wushan, 1885-88, *Henry* 5709 (E, G, K, NY); HUPEH. Changyang, *Wilson* 439 (NY); ex Hortorium Veitch, from Wilson's seed, 30 March 1907 (K). Without precise locality; Western China, no date, *Wilson* 4451 (BM).

The original description of *Pachysandra stylosa* var. *glaberrima* is very brief, consisting of only three words: "Tota planta glaberrima", and is based upon a single collection. During the course of this study examination of at least five sheets of this collection, in addition to specimens accumulated since that time, has made it possible to expand the original description.

Handel-Mazzetti's number 607 at Arnold Arboretum has been taken to represent the type, although he did not designate it as such. The type locality, indicated as Sanyingpan, located north of Yunnanfu could not be located with certainty. Considering the fact that the Chinese prefix "san" means mountain and the suffix "shan" may also be interpreted as

mountain, it is possible that Yingpanshan, located north of the Yunnan border and northeast of Yunnanfu (Kunming) is the same as Sanyingpan and thus the actual type locality.

The leaves and stems of specimens of the type collection are strictly glabrous as also noted in Handel-Mazzetti's comments accompanying the original description. However, other specimens which I am associating with this variety, contrary to the connotation of the varietal epithet, possess sparse pubescence, not apparent to the naked eye but with 10X magnification. The trichomes are present along the midrib and lateral veins on the lower surface of leaf blades and also on the stems.

*Pachysandra stylosa* var. *glaberrima* is most closely related morphologically to *P. stylosa* var. *tricarpa*. These differ with respect to the number of staminate flowers and the number of bracts of the pistillate flowers. There are 6-10 staminate flowers per inflorescence and 12-14 bracts per pistillate flower in *P. stylosa* var. *glaberrima*. In *P. stylosa* var. *tricarpa* there are 3-6 staminate flowers per inflorescence and 8-10 bracts per pistillate flower.

The following is a list of herbaria from which *Pachysandra* specimens have been examined. The standardized herbarium abbreviations of Lanjouw and Stafleu (1959) have been adopted. An asterisk following an abbreviation denotes a herbarium not in their list.

A	Arnold Arboretum, Harvard University
BH	Bailey Hortorium, Cornell University
BKL	Brooklyn Botanic Garden
BM	British Museum (Natural History)
CINC	University of Cincinnati
CM	Carnegie Institute, Pittsburgh
DUKE	Duke University
E	Royal Botanic Garden, Edinburgh
F	Chicago Natural History Museum
FI	Herbarium Universitatis Florentinae
FLAS	Agricultural Experiment Station, University of Florida
FSU	Florida State University
G	Conservatoire et Jardin Botaniques, Geneva
GA	University of Georgia
GH	Gray Herbarium, Harvard University
HK	Herbarium, Gardens Department, Hong Kong
ILL	University of Illinois
IND	Indiana University
K	Royal Botanic Garden, Kew
L	Rijksherbarium, Leiden
LA	University of California, Los Angeles
LD	Botanical Museum and Herbarium, Lund
LSU	Louisiana State University
M	Botanische Staatssammlung, München

MASS	University of Massachusetts
MICH	University of Michigan
MISSA	Mississippi State University
MO	Missouri Botanical Garden
MOAR	Morris Arboretum, University of Pennsylvania
MSC	Michigan State University
NA	United States National Arboretum
NCU	University of North Carolina
NO	Tulane University, New Orleans
NY	New York Botanical Garden
OS	Ohio State University
OSC	Oregon State College
P	Museum National d'Histoire Naturelle, Paris
PAC	Pennsylvania State University
PBDY*	George Peabody College, Nashville
PH	Academy of Natural Sciences, Philadelphia
POM	Pomona College
SMU	Southern Methodist University
TENN	University of Tennessee
TI	Botanical Institute, University of Tokyo
UA*	University of Alabama
UC	University of California, Berkeley
US	United States National Museum
VDB	Vanderbilt University
WS	State College of Washington
WVA	West Virginia University
YU	Yale University

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